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A Manual of Gas Distribution

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PREFACE

In 1898, the editor of this Manual accepted an invitation to aid in the organization of a distribution department for the Philadelphia Gas Works. For the first year or two the physical work was so extensive and pressing that no attention could be paid to the reduction to writing in convenient form of the rules for workmen, of the instructions for foremen and superintendents, and of the routine governing the relations with the other departments. However, in 1905, the field described above was adequately covered. Then it was that the editor began — at first, with only local use in mind — to plan a book which primarily would teach the prentice hand, in great detail, the principles of gas distribution at ordinary pressures, but which also would have something of value for the adept. This Manual is the result, and it may be regarded as only a start towards making available, in convenient form, the accepted principles of the art of gas distribution in this country. Hitherto, works on distribution have been available in English from British sources only, and these have fallen short of greatest usefulness in the United States because of the considerable difference in practice, in tools and in material obtaining in the two countries. American practice could be found solely by much gleaning from gas journals and association proceedings.

In the years since the first words were written, the editor has been under constant obligations to many of his co-workers, past

and present, for much of the material within these covers. He takes this opportunity of expressing his gratitude, but does not endeavor to list the names. He makes two exceptions, however, to the rule just established. Mr. H. B. Andersen has rendered most valuable assistance in general criticism and in preparing the material in Part IX. To Mr. P. A. Huber's untiring labor is due the excellence and uniformity of the printed page.

"I am a citizen of no mean city." In itself, service in a public utility corporation has many inspiring phases. In the gas industry, the employee at the works may take pleasure in the thought of how excellent a product is resulting from his labor, but the distribution man is privileged to come in contact with the public he serves, and by his attitude, largely to make or mar his company's fortunes. If this book aids a little in making our service even better than it now is, the labor of love in its preparation will have its full reward.

WALTON FORSTALL.

Philadelphia, Pa., January, 1920.

TABLE OF CONTENTS

Part I. Administration of a Distribution Department

Part II. Design of Outside System

Part III. Equipment

Part IV. Main Work

Section I. Installation

PART V. SERVICE WORK

PART VI. STREET LIGHTING

PART VII. METER WORK

Section I. Meters

Section II. Installation and Maintenance

Part VIII. Housepiping and Fixtures

Section I. Specifications for Piping and Fixtures

Section II. Installation and Maintenance

Part IX. Appliance Work

Section I. Organization

Part X. The Storeroom

Section I. Organization

LIST OF ILLUSTRATIONS

LIST OF SCHEDULES

LIST OF TOOL KITS

PART I

ADMINISTRATION OF A DISTRIBUTION DEPARTMENT

Under this heading will be found the general principles that should be followed in the administration of a distribution department. The treatment will be chiefly from the standpoint of a large company, as the few distribution men of a small company hardly may be said to form a department, or to require deep thought for their organization. However, much of what is written is applicable to every company, especially the very important question of keeping in touch with the work of each employee, so that effort may be stimulated and reward may follow effort.

SECTION I

SCOPE AND ORGANIZATION

CHAPTER I

SCOPE OF WORK

A distribution department should cover the whole field suggested by its name. Its work should begin not in the street mains just outside the holders, but at the *inlet* of all street main governors, for it is the distribution, and not the manufacturing, department that is acquainted with the relation between the capacity of the various trunk mains and the demand for gas through them, and a knowledge of this relation, coupled with that of the pressure needed to give good service, determines the schedule of pressures to be followed at each street main governor outlet for any hour of the day or year. The larger the company, the more important it is that this control of pressures should be directly under the distribution department. The ability to say what pressures should be carried, besides enabling proper service to consumers, provided such service is possible with the existing main system, is then coupled with the knowledge of any failure to furnish proper service.

The end of the distribution work should be just above the burner tip. In other words, meter, appliance and complaint work should be cared for by the same department that is responsible for mains and services. Frequently, and in very large companies too, the street department reporting through a superintendent of mains and services to a chief engineer, is separated entirely from the fitting department reporting to the secretary. The advocates of such a separation justify it on the plea that the official in charge of the consumers' ledgers should control all meter and complaint work, in order to ensure correct records and prompt attention to consumers. To meet this argument, there are many examples of distribution departments entrusted with meter work, and doing

it to the complete satisfaction of the office. On the other hand, delay and increased expense accompany all such divorce of fitting work from other distribution activities. Because of the fact that efficient operation requires all work of a similar nature to be done by one department, it also is a mistake to vest, as sometimes is done, the maintenance of various types of appliances with the new business department.

CHAPTER II

ORGANIZATION OF DEPARTMENT

Large City

The organization given is one applying in its entirety only to a city of over 500,000, but, as will be pointed out, its component parts may serve as models for distribution organizations in cities of all sizes.

The organization in its upper ranks may be diagrammed as follows:

Engineer of Distribution Assistant Engineer of Distribution	District Superintendents Superintendent of Meters Superintendent of Paving Superintendent of Records Superintendent of Stores Superintendent of Street Lighting Superintendent of Transportation Inspectors

Such an organization is adequate for the largest cities in this country.

Engineer of Distribution

The Engineer of Distribution would report to the General Manager of the company. The question as to the necessity for an Assistant Engineer, or an Assistant to the Engineer of Distribution, would be answered differently by different people. A good general principle to follow, however, in the conduct of all important work, is to have a capable understudy for every principal official. In this way, the latter is spared much detail and his mind left free to view his work in its broader aspects. Such freedom from the burden of routine work, coupled with the proper mental calibre, will produce improvements in apparatus and in operating efficiencies obtainable in no other manner. Nothing is more shortsighted than the policy of undermanning any staff charged with the control of a large expenditure. The salary paid to each assistant invariably may be saved several times over, with the right chief. Also, where there is

an assistant, the company is well protected in case the services of the chief are lost.

Assistant Engineer of Distribution

It will be noted on the diagram that the Engineer and Assistant Engineer are put side by side, rather than end on. The arrangement chosen is meant to indicate the method of working that naturally must obtain in the interest of efficiency and prompt action. This condition is that some matters will go from the superintendents to the Assistant Engineer direct, and be settled by him; others will be transmitted by him to the Engineer for final action; while still a third class will be sent straight to the Engineer, by the superintendents. For instance, the Assistant Engineer might look after and decide finally on most matters relating to main, service and fitting work, might formulate rules and instructions covering the operation of the department for submission to the Engineer, while the latter would specialize on meter and appliance design and repairs, and decide on the changes in personnel.

District Superintendent

The District Superintendent would be in charge of all distribution work in a certain area. Other things being equal, these areas should be so chosen as to approximate an equal number of meters, either at the time of division or (with reference to probable differences in development) at some time in the near future. Of course, in practice, physical conditions, such as water courses, railroad systems, etc., often govern the boundaries of these areas, but the number of districts probably should never be more than six, and more generally from two to four. The disadvantage of too many districts lies in the lack of street work that may characterize one or more districts during certain seasons. This involves either a regrettable discharge of efficient employees, or else working at increased cost. In actual operation, the transfer of men from one district organization to another is not effected easily and militates against the operating efficiency obtained by the district organization. Roughly, a district should contain at least 40,000 meters. As an upper limit, perhaps 150,000 meters might be taken. The advantage of more than one district lies in the opportunity thus afforded of pitting one District Superintendent against another, and this advantage is a very practical one, and should be utilized whenever the scale of operation will permit. A discussion of the question of district operation will be found in the 1909 Proceedings of the American Gas Institute, page 687.

In very large organizations, where a district superintendent may have charge of over 50,000 meters, the same reasons leading to the appointment of an Assistant Engineer of Distribution, make advisable the appointment of an Assistant District Superintendent in each large district. Besides the freedom from much detail thus afforded the District Superintendent, the Assistant Superintendent gains experience not possible in a foreman's job, and becomes qualified to fill a superintendent's position, preferably first in a small district.

The organization under the District Superintendent would comprise three general foremen, one each for main, service, and fitting work, and a chief clerk, who would be in charge of all clerical work. Whether the general foreman of mains and the general foreman of services should be independent of each other, or whether the latter should be regarded as an assistant to the former, is a matter depending largely on individual judgment and on local working conditions. Where these positions are independent, each general foreman stands squarely on his own basis. However, the dependence of the service foreman upon the main foreman, allows the use of a more inexperienced man in the former position than might otherwise be safe. Under the general main foreman would be as many gang foremen as there were separate main laying gangs employed. Under the general service foreman would be the various service gangs, and, in a large district, there would be several service inspectors, each looking after several gangs.

The general foreman of fitting work would have charge of all work done inside of buildings, this including complaints and all branches of fuel and lighting appliance work. There might be an assistant general foreman and also inspectors over the various classes of work. There should be one person, called a dispatching clerk, through whom all orders should pass to the individual men who actually do the work, either directly when the men report to the shop, or indirectly through the inspectors, when the latter carry out the work cards to their men. In this way, there always is one man who knows what the entire fitting force is doing, a knowledge which is essential on the many occasions when special jobs have to be done and a shifting of men is required. Also, the general foreman is thus relieved of routine duty and left freer to care for important work as it is met with, and, in general, to study where improvements, both in economy and efficiency, can be effected.

The chief clerk would be responsible for all office work and possibly look after any miscellaneous operations performed at the district shop, as, for example, repairing street lamps, various gas appliances, bicycles, etc. The chief clerk is the mouthpiece of the shop in its relations with the order desk, and should be the only person, with the exception of the District Superintendent, authorized to make any promises as to performance of work.

Superintendent of Meters

In many fairly large companies, the care of meters has been left to the District Superintendent and to the foreman of the meter shop. To the former, meter matters are no more important than any other interest committed to his care, while a meter shop foreman usually is too busy on routine work to spare any time for a broad view of meter construction and repair. On the other hand, as has been well shown by experience, the existence of a Superintendent of Meters, a man of the same calibre and pay as a District Superintendent, inevitably tends toward economy in every phase of meter work. The first cost of meters and the expense entailed by the various tests and repairs to which all meters brought in from use are subjected, amounts to hundreds of thousands of dollars yearly in the large companies. A study of design, which results in decreasing first cost, and of records of tests, which eliminates unnecessary work, will save the salary of the Superintendent of Meters many times over, and yet without such a man, the above savings are apt to be overlooked and practice continue in a rut

The existence of the Superintendent of Meters and of the other "special" superintendents already diagrammed as employees of equal rank with the District Superintendents, involves, of course, questions of divided control, and might lead to serious friction if the duties of each superintendent were not defined carefully. In Philadelphia, the scheme of special or, as they are called, "division" superintendents, has worked well. It is understood by every one that certain district employees are subject to a supervision of their operation by the division superintendent or his employees. The exact limits of the supervision, and how it is effected, have been worked out. When cases arise between district and division employees not possible of settlement by them, the two superintendents interested attempt to reach an agreement, in default of which the Engineer's Office (meaning the Engineer of Distribution, or his Assistant, or both) is appealed to for a final decision.

The Superintendent of Meters comes in contact with the district superintendents through the district meter shops. The work of these shops is discussed in Part VII. The character and extent of the work to be done at the district shop, as distinguished from the main meter repair shop, the workmanship displayed and, in general, the whole operation of the district shop, are subject to instructions from, and criticisms by, the Superintendent of Meters. An inspector from the main repair shop visits each district shop at regular intervals. He is under the foreman of the main shop, who, in turn, is responsible to the Superintendent of Meters for all meter repair work. A chief clerk has charge of the office work and meter repair records.

Superintendent of Paving

The character of the organization required to ensure the proper restoration and maintenance of all paving disturbed by street work, will depend not only on the size of the company, but also on whether the paving is done by contract or not. The advisability of contract versus company work is discussed in Chapter XXVI. In a large situation, where all paving is under contract, the existence of a Superintendent of Paving is well justified by the results obtained. He acts as the intermediary between the company and the city authorities, keeping in very close touch with the latter, and by his pleasant relations with them, protecting the company from arbitrary and unwarranted demands for the repairing of areas much larger than those affected by the company's work. He always is available to meet the city paving inspectors to determine by mutual agreement to what extent the bad condition of certain paving is due to company work. These inspections and the visits to city require much time, and yet are essential to economy in paving work. In the absence of a Superintendent of Paving, these duties would devolve upon (*1*) a subordinate official called, say, an Inspector of Paving; or (*2*) upon the Assistant Engineer of Distribution; or (*3*) upon the District Superintendent. The objection to (*1*) is that a man of inferior position is at a disadvantage in all his relations with the city employees. His calibre usually is not such as to enable him to meet, on an equal footing, the men in charge of the city's paving, and he is of the same class as, instead of superior to, the city inspectors, with whom he decides upon paving repairs. Actual superiority is quite a practical advantage in the last instance. The objection to (*2*) is that the Assistant Engineer has more important work to do. The objection to (*3*) is

that the District Superintendent's work does not lend itself to killing time waiting on city officials, and also that it is not wise to have several different men speaking for the company on the paving question.

Where the paving is done under contract, the Superintendent of Paving would receive a record of all openings, preferably on cards, transmit the proper notices to the contractors and the city authorities, inspect more or less of the work, and check the contractors' bills. The systematic inspection of all paving work, involving perhaps three inspections of every job, could be done by inspectors reporting to the Superintendent of Paving, or forming part of the district organization.

Where the paving is done by the company, it could be under the direct charge of the Superintendent of Paving, or of the District Superintendent. The latter course is preferable, for it will permit the repaving being done by the same gang that makes the opening, and this practice conduces to economy in many cases of isolated openings. Also, as the inspection should be made by men not belonging to the department doing the paving, when the latter is performed by the district organization, the inspection of the work very properly falls to the employees of the Paving Division.

Superintendent of Records

The existence of a Records Division is based on the belief that the main laying foreman should not be hampered in his work by the necessity of taking records. The organization of the record work is given in Chapter XXVII.

Other branches of work sometimes falling to a large distribution department, and which in Philadelphia have been entrusted to the Superintendent of Records, are (*1*) the inspection of cast-iron pipe and brass cocks; (*2*) the supervision of all building work and the periodical inspection of buildings; (*3*) the supervision of a messenger service maintained between the various offices and shops; and (*4*) any special work that may arise.

(*1*) The inspection of cast-iron pipe and brass cocks is cared for by an inspector at each foundry. Over all the inspectors is a Chief Inspector, who also assists the Superintendent of Records in other ways. The advisability of such inspection is treated of in Chapter XII.

(*2*) Building work, usually involving the preparation of plans, falls naturally to the Records Division. The inspection of such

work during erection by the person responsible for the design, has manifest advantages. The periodical inspection of existing buildings insures proper upkeep, and is better under one man than under many, as would be the case if each superintendent inspected his own buildings.

(*3*) A private messenger service saves time and money for a large company, but needs constant supervision to be kept at high efficiency. This supervision is exercised by the chief clerk of the Records Division through a Chief Messenger.

(*4*) Under the head of special work comes preparation of plans in certain accident cases, miscellaneous drawings, etc.

Superintendent of Stores

The exact costs of the various details of distribution work cannot be ascertained without a "storeroom" system, viz., a method by which materials as bought are charged to a "Storeroom" account, and then charged out as used. It is easy to charge to "Storeroom" all the material received, as per receipts sent in by the various storekeepers. It is quite difficult, on the other hand, to ensure that this material, scattered, as it is, through district storerooms and in wagons and working kits, should be so generally reported that at inventory time the stock found will agree closely with that shown by the storeroom books. As long as the responsibility for stock discrepancies rests only with the district superintendents, or with an employee of minor rank, such as a working storekeeper, so long will there be, each year, annoying disclosures, and balancing entries needed to make book records agree with inventories. The District Superintendent has many other things to do beside looking after material stock, and a working storekeeper is too busy with detail to handle properly the storeroom question. A Superintendent of Stores, however, responsible for the clerks and storekeepers at the main storeroom, and consulted as to the district storekeepers, has, as his sole business, the proper handling of material stock, and is paid a salary sufficient to ensure a competent man. The result has been, and always can be, a general close agreement between actual and "book" stock, with the resulting assurance that material costs are correct, and the gratifying absence of much time wasted in trying to locate discrepancies.

The existence of a Superintendent of Stores, with his accompanying organization, also guarantees a better relation between stock on hand and current needs for material, than is apt to obtain when

the responsibility for deciding as to time, or size, of order rests either with a storekeeper or is divided among several district superintendents. Only those who have had the experience of looking after the material needs of large companies through periods of great business activity, both in company and in nation, can appreciate how difficult is the task of always keeping a supply of everything on hand without getting overstocked on certain lines. The judgment needed for such work may be obtained only by paying what the job is worth, and not treating it as something only a little better than a clerk's or storekeeper's position.

Just as the Superintendent of Meters keeps in close touch with the district meter shops by means of a visiting inspector, so the Superintendent of Stores watches over the district storekeepers. Details of storeroom work are given in Part X.

Superintendent of Street Lighting

With the advent of the electric arc light, street lighting was very largely lost to gas companies. Now it is being more or less regained by the aid of the Welsbach mantle. Generally, however, these incandescent gas lights are maintained by a lighting company, to whom the gas is sold, and, consequently, few gas companies need a street lighting force. The Philadelphia Gas Works for a while was an exception, as it cared for 24,000 street lights, all flat-flame burners. It employed a Superintendent of Street Lighting, a Chief Inspector, three inspectors, two clerks and a stenographer, and about one hundred and forty lighters. Through the inspectors was maintained a systematic inspection of every light and the work of every lighter. The office force handled all the orders for the erection, maintenance and removal of lamps, and made up the lighters' payrolls. Further detail of this work is given in Part VI.

Superintendent of Transportation

In these days of motor vehicles, it hardly is probable that any large distribution department is doing all its transportation work with horses, or owns enough of the latter to justify a Superintendent of Stables as distinguished from a Superintendent of Transportation. For many years, in Philadelphia, there was a Superintendent of Stables, and his existence as an employee of equal rank with the other superintendents produced results well worth the additional salary expense. The equipment was maintained in excellent condition at all times and thus served

as a very good advertisement. The Superintendent of Stables was held responsible for the provision of suitable horses and wagons for distribution needs. He employed and exercised complete control over all stable men and drivers who did no district work. He was consulted in regard to drivers acting as district workmen. He had a right to interfere whenever he was not satisfied with hauling conditions in any district. This organization was a great improvement on the plan of leaving the care of horses and wagons to the district superintendents through individual stable foremen. The usual result of this arrangement is that horses are rather poorly cared for and wagons become shabby and dilapidated.

To meet the conditions of mixed transportation now generally existing, there should be a Superintendent of Transportation, caring for both horse-drawn and motor vehicles, through inspectors of horse and motor transportation respectively. The former would correspond to a superintendent of stables, though with much fewer horses to care for than would justify a superintendent's position. The latter would be in direct charge of all motor transportation, this involving supervision over the various mechanics attached to the district garages and to a main repair shop, if any.

In a large situation, there would be an automobile for each district superintendent and any other superintendent whose duties involved much moving about; Ford cars or motor cycles for general foremen and various inspectors, as well as complaint men in scattered territory; three-wheeled vans or side cars for light material; and various types of motor wagons. Such equipment would justify a large repair shop at which all repairs could be made, only minor ills being cared for at the district garages. Also, until the relative worth of each type of equipment and its suitability to the work given it was known, an Inspector of Traffic Handling might justify his existence. This, with proper accounts to show the hourly cost of each mode of transportation, would aid in solving the more or less difficult problem of determining the most efficient motive power as between horse, gasoline and electricity.

Inspectors

The men included under this title, with their duties, are described in detail in Chapter X. As will be seen by the diagram, they report to the Engineer or Assistant Engineer.

Small City

By definition at the beginning of this chapter, a small city has a population of less than 500,000. Let us now further subdivide, distinguishing as between cities over and under 100,000, and considering the most populous class first. Such a city (unless its physical layout is peculiar) probably would be served most economically by one distribution shop, especially if this was not at the works, which latter could serve as a second storeyard for heavy material, diminishing hauling charges as against one storeyard for the whole city.

The distribution organization would be as follows:

Superintendent of Distribution	General Foreman of Mains General Foreman of Services General Foreman of Fitters Foreman of Meter Repair Shop Stable Boss or Garage Foreman General Storekeeper

The Superintendent of Distribution would report to the General Superintendent or Manager. His duties would be similar to those of the District Superintendent in a large city. The three general foremen would likewise be comparable to the same positions as already described in connection with a district organization. The meter repair shop might come under the General Foreman of Fitters, but it is preferable to have its foreman responsible directly to the Superintendent of Distribution. The Stable Boss as furnishing horses, the Garage Foreman, motor wagons, and the General Storekeeper, supplies to all branches of distribution work, should also report directly to the Superintendent. The number of minor foremen and inspectors required will vary according to the volume of work.

In cities under 100,000, the distribution work probably would be looked after by the manager or a superintendent. To him would report either a general foreman controlling individual main and service gang foremen and fitting inspectors, or in still smaller situations, the individual foremen themselves.

In conclusion, it may be stated that in planning an organization, great or small, two principles always are to be borne in mind: first, to have enough men for the work, and second, to have each man's duties well defined in order that initiative may be encouraged and responsibility properly located. In general, an organization that cannot be diagrammed easily is probably at fault.

SECTION II

OBTAINING, ASCERTAINING AND COMMUNICATING RESULTS

CHAPTER III

OPERATION BY COÖPERATION

The larger part of distribution work is done indoors. It is also the most important part, because it involves close contact with consumers, and unless it is performed in such a manner as to secure popular approval, no degree of efficiency in main and service work will avail to win popularity for the gas company. The question as to what charges should be made for any or all of this indoor work, has no place in a distribution manual. The problem of the distribution department is to carry out the policy decided upon in the most economical and efficient manner.

To solve any problem of this kind, men and means are requisite. A careful selection and treatment of men will do much to improve results. This is treated of in Chapter V as "The Personal Equation." Now will be considered how the distribution force, as a body, should be handled in order to benefit by the experience of the many, and yet simultaneously to obtain such a fusion of ideas that unity of thought and action among widely separated bodies of men may be preserved. Of course, the details of treatment will vary in each particular location, but a description of the building up of the Philadelphia Distribution Department will illustrate the principles involved better than would a general statement of them.

Upon taking over the Philadelphia Gas Works from the city, the existing distribution department was found to be entirely inadequate, and in its place was developed an organization substantially as described in the preceding chapter. In the rush of work required

to retrieve the neglect of past years, there was no time to compile general rules for the conduct of the department. As one question after another arose for decision, circular letters were sent to the superintendents concerned. Occasionally, before a decision was reached, the district superintendents and any of the division superintendents whose work might be affected by the subjects to be discussed, were called in conference. These irregular meetings proved so helpful that it was decided to hold them fortnightly, the thought being that no time could be spared during ordinary working hours. A few meetings, however, not only showed the disadvantages of adding to the work of a busy day, but also how valuable was the benefit to be derived, entirely justifying a daytime hour, even though other work was delayed thereby. As a result, for many years, meetings known as "Superintendents' Meetings" have been held every Tuesday afternoon, from two until four or five o'clock.

At first, only the questions actually decided at a meeting were covered by circular letter. Soon the thought occurred to summarize every principal subject of discussion, and this was the beginning of a regular circular letter, entitled, "Minutes of Superintendents' Meeting." Other circular letters not connected with these meetings were issued from time to time, and in several years the sum total of all the circulars became so considerable that it was not always easy to find quickly the latest ruling on any particular point. This difficulty was met by the preparation of an index comprising all the subjects covered by the distribution department, and each district superintendent was sent a set of cards containing all previous circulars properly indexed to date. From time to time additions to this index were sent out, until it was decided to index each letter as written, and this practice, conjoined with a serial number for each letter, and the numbering of each paragraph in the "Minutes of Superintendents' Meeting," absolutely identified every entry on the index cards.

The index was a great step toward putting the responsible employees of the distribution department in possession of the rules laid down for their conduct under the many diverse conditions that constantly were arising in their contact with the public and the other departments of the company. The necessity for intimate knowledge of the rules on the part of these employees was increased by the preparation of manuals of instruction for the guidance of the individual workman, as in a number of instances these manuals directed the workman to ask the "office,"

or his foreman, for guidance. The cards, however, contained many references to rules either entirely obsolete, or partially changed to meet later conditions. Therefore, a codification of all existing instructions was undertaken, and this resulted in "The Digest," containing about 300 typewritten pages of 300 words each. With its appearance, the task of the chief clerks in the district superintendents' offices was lightened greatly, for the Digest swept away all previous circulars, and, with the manuals of instruction, covered the whole field of the distribution department work.

As almost every week witnesses some slight change in practice, found wise to meet new conditions, the Digest is in need of continual amendment. This amendment is made half-yearly, by means of a circular letter stating what changes are to be made, giving page and line where the change is slight and enclosing a rewritten page where much is altered. At the same time, another circular letter tells how the various circulars that have been issued since the last Digest revision, are cared for in the present revision. In this way, there is a periodical cleaning up of all temporary letters of instruction, so that at any given time, the practice of the distribution department is represented by the Digest as last revised and those circular letters issued since that revision.

As might be expected, this clean-cut method of enabling all employees to know exactly what their duties are, has resulted in economy as well as efficiency of operation. The whole process was one of a logical evolution, and the benefits that resulted should be credited to the weekly superintendents' meetings and to the principle thus established of operation by coöperation,—the managing of an organization by freely consulting with those engaged in carrying out the work.

CHAPTER IV

PREPARATION OF RULES

In the preceding chapter, a description was given of how the general set of rules governing distribution operation in Philadelphia had been evolved, and the statement was there made that manuals of instruction had been prepared for the guidance of the individual workman. These manuals were just as much a slow growth as were the general rules which finally became the Digest, and equally represent the result of coöperative working.

One manual was for main and service men and the other for fitters. Each was the subject of many discussions and of free criticism from, and suggestions by, the district superintendents, who in many cases reflected the ideas of their foremen. The endeavor throughout was to prepare a set of rules that would be reasonable and could be enforced; to meet, not theoretical conditions, but those of daily work. These conditions, in the case of fitters trying to execute various classes of meter orders, sometimes are very complex, and much thought was required to set out clearly what was to be done in each of the many contingencies that might arise. In some cases, graphical representation was used in the interest of clearness.

Just as with the Digest, it was realized that the rules for the workmen would need to be changed constantly, and, by means of blank pages, easy provision was left for subsequent insertions. Any set of instructions, whether for day laborer or superintendent, that does not receive continual amendment to correspond with the constant changes occurring in every operating concern, soon loses its value as a correct guide to daily work. Yet experience shows that many persons are able to draw up a pretty fair set of instructions, which may cover existing conditions, but which soon need change, and lacking this, grow of less and less assistance until finally their existence may be forgotten, and practice is governed by memory, or by more or less disconnected circulars. As soon as this becomes true, efficiency and

responsibility are both lessened greatly. When, on the other hand, the head of the department ensures that its policy is embodied in frequently revised and adequate books of instruction, each employee can be expected rightly to justify any action by reference to page and line covering the case.

In compiling rules for the individual workman, it often is hard to decide how much knowledge he should be presumed to have of what may be called the practical side of his work. For instance, should a fitter be told how to set a meter, a service man how to run a service, or a caulker how to make a joint? The answer should be "Yes, whenever these jobs or any others should, in your opinion, be performed in a certain way." Of course, if there were available a treatise on the arts of main laying, service running and meter setting acceptable to all gas engineers, nothing covered by such treatise need be included in the rules. In this country, however, no such treatise has been in existence, and, therefore, distribution practice in any company is either what the men or foremen have learned, or what the engineer desires, as expressed wholly by word of mouth, or partly so, supplemented by written rules. Naturally, where precautions having to do with the safety of persons are concerned, the proper method is to embody such precautions in clearly expressed rules. Then, if accidents do occur, not only will the company be in a stronger position of defense against claims than it would be if no written rules existed, but also the responsible official will feel as if he had done all he could to minimize the chance of an accident.

CHAPTER V

THE PERSONAL EQUATION

The two preceding chapters have discussed the advantages to be gained by coöperative working conjoined with definite instructions. No organization, however, no matter to what degree its details have been worked out, is very effective unless the human element is of the right kind, and is actuated by the proper spirit. In employing men, personal appearance goes a long way, and for most subordinate positions, especially for street work, has been the only test usually applied, but much more attention will be paid in the future to the fitness of the man for his job. Considering higher positions, such as foremanships, the practice in Philadelphia has been to restrict these to college men, who thus may prove that they possess not only the brains, but also the executive ability to handle any distribution job. In choosing each college graduate, the head of the department in which he studied is consulted, and of late years various complete card records of each man viewed from many standpoints other than that of studiousness, are available. When a man combines personal attractiveness with a good college record, as above described, his chance of success is above the average. After employment, he is watched carefully, told of his defects when necessary, and given full opportunity to learn every detail of distribution work. This method has developed some very promising men. The idea throughout is to make each man feel that the Engineer of Distribution and the District Superintendent are anxious to do all in their power to help him succeed. If there is failure with one set of conditions, a second and perhaps a third trial is given under what are considered more favorable auspices. When a lack of endeavor shows conclusively, the man is told to seek other work, and allowed a reasonable time in which to resign. In cases where there seems to be ability, but not for distribution operation, a little trying out often results in finding work which can be done with credit.

While the rank and file of distribution employees are too many, and are not possessed of innate possibilities sufficient to warrant such personal attention as is profitable in the case of the college graduates, yet, in general, in order to obtain a higher than average character in, and performance from, a body of men, intimate and pleasant personal relations ought to exist between *all* ranks, as far as contact during work hours is concerned. In considering a large distribution department, it has been shown how the weekly meetings of the superintendents tend to unity of working. They also are indispensable as forming a social bond between men who otherwise would seldom meet. In the absence of this bond, the comparison of cost reports might tend to provoke enmities and jealousies, naturally disastrous to the best interests of the department. These meetings came to be regarded as quite an event of the week, where before the business session begins there is an opportunity for a little smoke, gossip and friendly joke.

Each district superintendent should see that foremen and chief clerk meet together often enough to preserve the unity of district work and to benefit by mutual suggestion. The foremen should meet periodically their men as a body (this applies particularly to the fitters) to lay stress on new rules or on phases of long standing rules in reference to which misunderstanding or carelessness seems apparent. All along the line the attempt should be to make each man feel that he is liked, as this policy undoubtedly will increase the work output.

However, no matter how conscientious a man may be, or how much he likes you and wants to show his liking by his work, human nature is such that, as a rule, his ultimate possibilities will never be known, either to you or to him, until he feels that extra endeavor will receive proportionate reward. This trait has been the main factor in the tremendous advance in economy of performance made in all lines of work where proper unit costs have been obtained and studied. Until late years, the expenses of the distribution department have not been divided properly. Now, as will be discussed in the next chapter, the means are at hand to watch every cent of expense. When this is done, and by it is seen what employees deserve credit for economical result, then they should be given appropriate reward, so that every one will know that good work means better pay in the same position, or a better position, or both. In the case of the laborer paid by the day, the ability of the foreman to feel sure that his recommenda-

tion to the superintendent will mean an increase for the man, adds tremendously to the foreman's ability to speed up the whole gang. As the superintendent holds the foreman responsible for economical operation, being in turn answerable to the distribution heads, the latter can look on increased wages for the laborer with unconcern, as long as the increases spell economy.

One of the biggest gains to be expected from the universal use by all the gas companies in the country of the "Uniform System of Accounts" of the American Gas Institute, would be the chance for comparison in cost of operation, a comparison which would have the inevitable result of showing in what cities lay the weak spots. They certainly would be found where no unit costs were kept, and where men in about the same position were considered to be more or less all alike and paid accordingly, without any reference to the fact that one man might be doing work more cheaply than another.

In conclusion, and to summarize — Select carefully, know individual performance, ask for results, and pay accordingly. The larger the company, the more important naturally will be the resultant saving.

CHAPTER VI

FORMS

Reason for Forms

A good personnel, furnished with the most complete set of instructions, needs the additional help afforded by an adequate system of forms. Occasionally, both circulars of instruction and forms are referred to as so much red tape, and of course, both these aids to organization can be over-elaborated. However, it is a safe rule to follow that whenever definite information is wanted, especially from the individual workman, the more clearly this information is called for by the sheet on which the report is made, the more satisfactory will be the result. Therefore, any change in the character of the information hitherto recorded will demand either an additional form or a change in an existing form.

Design of Forms

A form should be the embodiment of what existing experience has shown will best meet the varying and perhaps somewhat contradictory requirements of the purpose for which it is designed. The various points to be considered in the design of forms will now be discussed.

Number

Every form should have a number, thus enabling its easy identification in circular letters and manuals of instruction. Because of the advantage of such reference by number only, this number should not be changed as long as the form maintains its identity. Thus, a new edition of an instruction book to fitters should bear the number of the former edition, and also any change in the wording on a meter card should not mean a different form number. The date of printing on each edition prevents any confusion that might arise from the same form number being assigned to different wordings, and the chance of

any such confusion would be small in any case, as one edition does not go into use until the other is exhausted.

Title

Every form should have a title or *name*, which should be as distinctive as possible in describing its purpose and in differentiating it from other forms, especially those somewhat similar in character. In the evolution of a form's use, changes may be made that render advisable a slight change in title but not in number. At the top of the form, above the title, should be printed, if anywhere, the name of company and department. On small forms, and whenever space is limited, these designations are probably not justified, but under other conditions they add to appearance and completeness.

Arrangement

The arrangement of the matter on a form is of great importance, and is worthy of much study. In designing a new form, the first draft usually will follow the order in which the information desired comes to mind. This order usually requires modification in order to provide, as far as possible, for uniform width of columns, for convenient locations of significant numbers, remarks, etc. Also, any possible standardization of arrangement in connection with forms of similar nature, should be considered. For instance, all order cards should have name and address, and all meter cards, their meter information, in a uniform order. To be of the greatest value, all such standardization of arrangement should be based on the convenience of posting to or from the form. Where there is a logical sequence in which certain data is obtained most easily, that sequence should, of course, be used on all forms containing this data. A close attention to these details may be productive of much economy.

Spacing

Proper spacing of the matter on a form is quite essential to ease of obtaining information from it, especially where the reports are made by workmen using pencil. In such a case, every endeavor should be made to leave generous room where the report will be voluminous, and economize where "Yes" or "No" is apt to be the answer. Also, wider lines are needed than if the form is to be filled out by a good writer in pen and ink.

For office forms, where the typewriter is available, the line spacing should be that of the typewriter, and unnecessary side shifts avoided. After a new form has been in use for some time, a study of the reports made on it generally will indicate that a number of changes in spacing can be made with advantage in the next edition.

An incidental advantage connected with a proper study of spacing is that it naturally leads to the preparation of a neatly drawn scale copy for the use of the printer. Such a copy not only ensures more accurate work, but by reducing the printer's labor, results in closer bidding on his part.

Wording

The wording on a form may be of great value in insuring a correct report. For instance, in fitting work, where green men often are employed in large numbers at times of peak load, every form used should convey a clear idea of the report expected. In this connection, standardization is of as much importance as it is in the case of arrangement.

Printing

All printing should be in type of such size and character as to be easily legible, even to men with defective eyesight. Where space is limited, abbreviations often may be of value in permitting larger type. Standardization of type also will prove advantageous.

Ruling

Ruling is an expensive operation. It often is called for unnecessarily where the desired lines could as well be made by printing. When ruling is required, expense can be saved by avoiding multiplication of colors and column lines of unequal lengths. The cheapest form of ruling is where the lines pass entirely across the sheet.

Size

Size is governed primarily by the amount of matter required. Within the limits imposed by convenience of handling, all forms should be large enough to contain ordinarily a complete report on one sheet, without the necessity for close writing and consequent illegibility. It is surprising how well these requirements can be met by the use of only a few sizes in a system of several hundred forms. Beginning with the smallest, the standard library bureau card, practically 3 by 5 inches, is sufficiently large, and a

convenient size for the various order cards used in distribution work and for any schedules of sizes or charges needed by the workmen. This uniformity in size enables the workman to carry all his orders and data compactly and cleanly in a holder. It also affords a ready means of maintaining a record of all work at any address, by a geographical filing of completed cards. The next size, $5\frac{1}{2}$ by $8\frac{1}{2}$ inches, is one-quarter of 17 by 22 inches, a standard paper size in which most printers carry the largest varieties of papers, and is suitable for linewalkers' reports, street leak work, applications for abandoning mains, tool and material order slips, etc. The third size, $8\frac{1}{2}$ by 11 inches, is just twice the second, and is standard letter size. It is, therefore, adapted for all letter files, and when forms of this size are attached to correspondence, there are no overlapping edges. It can be used for applications for new mains, monthly cost sheets, and inventories, and, in general, will prove large enough for any form. The instances where larger forms are absolutely necessary will be so rare as to be distinct exceptions to the general rule. Among such will be book forms, of which, however, a distribution department needs but few. With them, a little care will make uniform, sizes that otherwise would differ by an inch or two, and shelve badly together.

Generally, a little allowance should be made on all the sizes to enable some trimming after printing, as the requirements of exact size usually will increase cost.

Material

There sometimes is a choice between cards and sheets either loose or in pads. For work orders to be filled out on the street, the card is preferable for ease in manipulation and preservation of shape and condition. If the completed orders are filed, this is an additional argument for a card. Usually, its thickness and consequent stiffness is controlled by the necessity of writing it in triplicate, one copy for the office, one for the shop, and one for the workman. The quality of paper, and in the case of books, of binding also, should depend entirely on the use to which the form will be subjected, both during and after filling out. Where the information is of temporary value solely, a much poorer quality of material will suffice than when not only the information becomes a permanent record, but also the form undergoes hard handling before filing. Another point to be remembered is that when for ease in distinction, color difference is employed, the

various tints should be selected with careful thought as to the effect on the eyes of any reader. This is important especially when order cards on store-room orders are edited by a night force.

Maintenance of Forms

Where the forms in use are in the hundreds, an individual card record of each form will be of great help in stock-keeping. On a smaller scale, a copy of the form itself may be used for the desired record, especially where the proper custom is followed of printing on each form the date and size of order. A complete set of the latest editions of all forms, arranged numerically, either in a loose-leaf scrap book or in folders, an alphabetical index of titles with accompanying numbers, and a numerical index showing where each form is mentioned in a manual of instruction, will together enable instant reference to, and knowledge of, the use of any form. This information is of great value when discussing any proposed changes in practice, especially when ordering new editions of forms whose necessity or character are still open to discussion. Such a consideration of possible changes when ordering new editions of existing forms often results in discontinuing practices no longer of worth, and, in general, before reprinting old forms or starting a new one, criticism should be invited from all qualified sources.

The number of copies to order may well deserve careful consideration. Where the form has been in use a long time, and, therefore, has proved its value, a year's supply probably will be the most economical quantity, bearing in mind the cost of clerical work entailed by the passage of an order through store room and purchasing agent. Of course, when postal cards in large quantity are involved, this rule will not hold, and three months should be substituted. When there is reason to believe that use will suggest changes not otherwise knowable, and especially if the cost of composition is a considerable item, then manifestly only a small edition should be printed, or, better yet, the first copies made on a mimeograph.

The length of time to allow for ordering will often depend upon local conditions. In general, ample allowance should be made for delay, because an order which must be hurried is a source of great expense and annoyance to both purchaser and printer.

As fast as new editions are printed, a copy of the last edition should be filed away with any previous copies of the same form.

In this way, there will be a historical file showing the development of each form. When any form number becomes obsolete, the entire set of copies of this form should be transferred to the file of obsolete forms.

The general supervision of forms should be under one of the distribution heads, as, by proper management, this will not require much of his time, and the subject requires a breadth of view not possessed by a subordinate employee.

Disposition of Forms

This subject covers the disposition of all distribution records. Each day witnesses an accumulation of records of varying degrees of value. Not only in distribution departments, but in the world in general, the important is lost to sight by being buried under the trivial. Instead of preserving every record until such time as lack of storage space forces a possibly ill-considered disposition of a certain percentage, there should be a carefully thought out schedule covering the length of time each record should be kept. In this way, things of no worth are being disposed of continually, making access easier to important records, for no matter how thorough may be the method of filing, it is true, especially with correspondence, that the smaller the residue kept, the quicker it may be located. This disposition schedule should be revised as experience dictates.

Note — Valuable information about forms and their printing will be found in a paper by W. P. Baylie on "Printing and the Care of Printed Stock." Proceedings of the American Gas Institute, Vol. IX, page 1708.

CHAPTER VII

ACCOUNTS

Reason for Accounts

The primary reason for the subdivision of the expenses of a company into various accounts is, of course, to obtain a knowledge of the amount of each different class of outgo. Theoretically, no cost incurred by a subdivision of expenses is justified unless it is less than the value of the knowledge so obtained. One particular use to which this knowledge may be put, — a use that is often neglected, — is to decrease operating expense by obtaining units costs in all lines of work. How the possession of such unit costs effects economy, will be discussed later. To be of value, however, these unit costs must be based on the various classes of jobs performed by the workmen. In other words, the accounts must represent adequately the different phases of the company's work. In the past, this has been more nearly true of the manufacturing than it has of the distribution end of the gas business, where one favorite plan was to have two large dump accounts, viz., "Distribution Labor" and "Distribution Material," which covered most of the *maintenance* (as distinguished from repair) charges and which defied analysis when attention was drawn to either because of a sudden increase.

A great step was made toward the securing of rational accounts by the report of the Committee on Uniform Accounts of the American Gas Light Association in 1902. While the accounts there advocated did not secure widespread adoption, and were capable of improvement, yet they were superior to any other system available for public use, and, in general, furnished proper unit costs. They included in one account both material and labor, a rational as well as necessary grouping, for often a true idea cannot be obtained of a unit labor cost without the knowledge of the accompanying material cost, for between jobs of the same class, the labor cost should be proportional strictly to the material used. In any one account, the labor costs always

are separated easily from material and miscellaneous charges, by merely subtracting the payroll charges against the account from the sum of the other charges.

The "Uniform System of Accounts" as adopted in 1914 by the American Gas Institute, provides a classification designed to meet the requirements of the various public service commissions, and yet enables the obtainment of proper unit costs. For the reason already stated, it is greatly to be desired that these accounts should be adopted universally.

Important Accounts

Large City

In such a city as previously defined, the accounts of peculiar value to a distribution department are as follows: (The nomenclature of the Institute accounts is used.)

Asset (or Construction) Accounts:
- (1) Trunk Lines and Mains
- (2) Services
- (3) Meters
- (4) Meter Connections
- (5) Street Lighting System

Operating Accounts (covering expense caused by existing consumers):
- (6) Maintenance of Mains
  - (6–1) Relaying Mains
  - (6–2) Overhauling Mains
  - (6–3) Drip Expense
  - (6–4) Watching Mains
- (7) Maintenance of Services
  - (7–1) Relaying Services
- (8) Maintenance of Meters
  - (8–1) Meter Repair Shop
- (9) Resetting and Removing Meters
  - (9–1) Turn On and Off Expense
- (10) Service Expense
- (11) Consumers' Premises Expense
  - (11–1) Fuel Appliance Expense
  - (11–2) Lighting Appliance Expense
  - (11–3) House Pipe Inspection
- (12) Distribution Office Expense

Operating Accounts (covering expense incurred to obtain additional consumption):

(13) Housepiping, Lamps and Fixtures

(14) Connecting Gas Appliances

(14–1) Gas Range Connections

(14–2) Water Heater Connections

(14–3) Industrial Appliance Connections

In discussing these accounts, no attempt will be made to give all the information necessary to use them. For such details, the "Uniform System of Accounts" should be consulted. The aim here is simply to indicate along what lines expenses should be divided, in order that the figures so obtained should be of value both in indicating the cost of existing policies toward consumers and in reducing the cost by promoting operating economies.

(1) Trunk Lines and Mains: A separate account should be kept by size for 4, 6, 8 and 12-inch pipe laid each year, and an individual job cost for larger sizes. In this way, reliable costs per foot for labor and material are obtained for each size.

(2) Services: It is seldom of any advantage to divide service costs by size, as usually 85 per cent or more of the services are of one size.

(3) Meters: Self-explanatory.

(4) Meter Connections: The cost of connecting new meters is charged to "Meters" in the Uniform System, but the value of a unit cost for setting meters will justify any company opening a separate account for this purpose.

(5) Street Lighting System: This account would be necessary where a street lighting system was being extended continually.

(6) Maintenance of Mains: This and the six following accounts may, as the headings indicate, be considered as being incurred because of existing consumers. The accounts to "Service Expense" inclusive, refer to expenses that are inevitable, and for which, as a rule, no charge can be made to consumers. "Maintenance of Mains" covers the whole cost of operating and maintaining the street mains. "Relaying Mains," "Overhauling Mains," "Drip Expense" and "Watching Mains" are possible subdivisions of it, any or all of which local conditions may demand should be kept in addition to the account itself, which would then represent all street main expenses not cared for by the subdivisions. It is easy to see that during any year

when much relaying or overhauling of the mains was in progress, "Relaying Mains" and "Overhauling Mains", divided into sizes and kept as between various districts, or gangs, would furnish valuable records for future estimates of similar work, and by the magic effect of unit costs, cause operating economies. "Drip Expense" would give information valuable in a large situation, but can be obtained rather easily without opening a separate account. So also can "Watching Mains," which would be justified only as a separate account in a very large city where continued disturbance of underground conditions occurred.

(7) Maintenance of Services: This account covers the whole cost of operating the services. A service should be considered as ending at the inside of the cellar wall. Any point between that and the meter belongs naturally to meter work. (See previous remarks regarding "Meter Connections.") Certainly so when the work itself is not done by the service layers, or at the same time as the outside work. Otherwise, useful unit costs will not be obtained. As services are being renewed continually, a separate account, "Relaying Services," should be kept, covering the cost of this relaying work. The unit costs per foot and per service for labor and material will be, next to the similar costs for new services and those for mains, among the most valuable of distribution work.

(8) Maintenance of Meters: Where all repair work is done by the company in one shop, or all repairs are sent out, it is easy to know the cost of repairs without opening a separate account. In large companies, however, where many minor repairs are made at district shops, and the total amount spent is large, "Meter Repair Shop" should be opened. Certain phases of work on meters, such as painting and testing where no repairs follow, if not charged to "Meter Repair Shop," would then go into "Maintenance of Meters."

(9) Resetting and Removing Meters: The general custom has been to include with the cost of setting and removing meters, the cost of turning on or off gas. This latter operation is, however, so much less than that of a set or remove that it becomes of great importance, when working on a large scale, to know exactly what this difference is, in order to determine the saving possible by shutting off meters in empty houses instead of removing them. Also, by the separation, two quite definite unit costs are obtained, instead of a cost representing the average of two very different operations.

(10) Service Expense: This account, formerly known as "Complaint Expense," records, principally, the cost of visits made to see what may be wrong with the gas supply, when the trouble is found to be on the street side of the meter outlet. Where thousands of visits are made, the possession of a unit cost conduces to considerable economy, as little material enters into this account, and there is no necessity for separating material and labor.

(11) Consumers' Premises Expense: This account covers the whole field of looking after the needs of consumers on the burner side of the meter outlet, and is capable of as great subdivision as the activities of the company may render advisable. The Uniform System draws a sharp line between the revenue and expenses incident to placing appliances, and those caused by the use of these appliances. The first set of accounts being sales accounts, often show a profit, and are closed into "Non-operating Revenues." The second set are considered as distribution expenses, and are lumped in "Consumers' Premises Expense." The disadvantage of this is that, although when trying to get the exact effect on revenues of an aggressive appliance campaign, it is possible to deduct any increase in "Consumers' Premises Expense" from increased sales of gas and profit on sales account, yet no information as to the details of this increase is obtainable. If various accounts are opened, of which "Fuel Appliance Expense" and "Lighting Appliance Expense" are merely suggestions, it becomes possible, over a term of years, to tell exactly what permanent increase in operating expense may have been caused by certain new business policies. Also, each such account opened, which enables work involving different operations to be shown separately, is a gain for economical operation. "House-pipe Inspection" by the Uniform System is placed under "Consumers' Premises Expense," though it really is expense incurred to get new consumers. In a large situation, the cost of this inspection should be kept separately, and if done by one or two men only, may be so kept without actually opening a separate account.

(12) Distribution Office Expense: This is more or less of a dump account, and does not yield easily to analysis. Yet, as will be seen later on, the clerical labor charged to it may be made to furnish a very valuable unit cost.

(13) Housepiping, Lamps and Fixtures: This is one of the accounts belonging primarily to the new business end, but of

interest to the distribution department as doing the work. It covers, besides the installation of lighting appliances, all piping run to secure new consumers, or increase the consumption of existing consumers, as distinguished from piping installed as a separate job to supply an individual fuel appliance. This is another dump account, and will not yield a satisfactory unit cost.

(14) Connecting Gas Appliances: This account corresponds in the connection of appliances to what "Consumers' Premises Expense" does in their maintenance, and, as indicated, is capable of as much subdivision as may be advisable in order to know what profit or loss is being incurred by the handling of each class of appliances, and also for what branch of the work the cost may be unduly high.

CHAPTER VIII

OPERATING DATA

Daily Reports

The establishment of unit costs was one of the determinants in the selection of the accounts useful in a division of distribution expenses. For such cost, we need not only a dividend, this being the amount spent on any account, but also a divisor, and this obviously is the number of jobs charged to this account. To obtain the various divisors required, a count must be kept of all the jobs concerned. Experience shows that the easiest way to obtain data correctly and promptly is to require their reporting as fast as they become available. In distribution work, a daily report admirably answers these conditions. Besides affording an accurate means of collecting data for unit costs, it also, because of such figures and of other information to be spoken of later, becomes a valuable aid to foremen, superintendents and the distribution head in keeping in touch with the current work of the department and the relations of such work, both in volume and character, with the work of any past period. Where, as is becoming more and more true of distribution work, with the increase in the number and varieties of appliances sold by the gas company to its consumers, there is a seasonal variation in the volume of orders, an inspection of daily report files will afford information as to the dates and durations of past "peaks" in various lines of work, which may prove of great value in deciding on the additional equipment in men and material needed at any given time. Especially is it true in the case of appliances that a knowledge of how they have been required from day to day in the past, will enable a more intelligent estimate of how deliveries should be arranged for, than any general idea that "so many thousand will be sold this year." A graphic representation of the daily report data relating to volume of work has proved a convenient way of seeing at a glance the relation between the periods under comparison.

Just what information should be supplied by the daily report will depend to a certain extent upon local conditions. In general, any data should be included that must be kept in any case, and, therefore, whose record on the daily report need not mean an additional entry. A description of the report used in Philadelphia for each distribution district may be suggestive, though probably it contains more items than would be required in a smaller situation.

Under "Mains," this report gives for each size of pipe, the number of feet laid, overhauled or abandoned that day, the total laid or overhauled since January 1, and the amount yet to be laid or overhauled according to instructions in the hands of the superintendent. This last information is valuable as showing, at a glance, the condition of the main work in each district. Under "Services" are the number of "new" and "renewed" services laid since January 1, the net gain for the same time, and the day's total of services laid, and also "abandoned, not renewed." Under "Street Lamp Work" are the new locations, relocations and removals for the day. Under "Meters" are the number in use, the daily sets and removals, and the total set since January 1. Under "Appliances" are the connections and disconnections, both for the day and since January 1. There is no figure for the number in use, as there are many connections and disconnections not made by the company.

Then follow data referring to various classes of stoppages and leaks. Stoppages are divided between lamp and house services, meters, house risers, and piping and fixtures. House services and risers are further subdivided into "frozen" and "other causes." Meters are subdivided into "water," "prepayment mechanism" and "other causes." In this way is obtained, with little trouble, information that as it accumulates from month to month and year to year, throws an interesting light on the effect of temperature in connection with meters and small services and piping, on the mechanical defects of prepayment meters, etc. Leaks are divided between main, service, meter and appliance leaks. Meter leaks are further subdivided into "meter," "washer joints," "meter cocks" and "meter connection" leaks. The subdivisions under appliances are "appliances," "gas lines" and "water lines." These leak data, especially that relating to meter work, have shown the necessity for radical changes in practice, and the improvement, or otherwise, resulting from each change.

The final feature of the report is a "Work Summary," showing for each account the number of jobs done during the day. The total number of these jobs accurately represents the district's activity, and the individual totals furnish the divisors for the cost reports.

Monthly Reports

There are certain data about which daily information is not necessary and, in some cases, could not be given exactly. Such data should be reported monthly. They include meter removal causes and tests by sizes, appliance connections by classes, details of street leaks, daily wage increases, and special facts that may be asked for from time to time. For all of these reports, a definite date of return should be fixed, and notice taken of delay. In this way promptness of receipt will be ensured.

CHAPTER IX

COST REPORTS

The preceding chapters of this section have told of the way in which an organization may be built up to enable the attainment of good results, and how these results may be ascertained by a proper division of expenses. We are now concerned with the expression of these results in appropriate unit costs, and their communication to the superintendents and foremen interested. The value of these two related actions arises from the constitution of human nature. Since man was, the highest achievement has been secured by the existence of a goal to be reached and of competitors to be beaten. The lowest possible unit cost is the goal which each superintendent and foreman is anxious to reach before his fellow. Therefore, a system that furnishes to each district superintendent monthly, a report showing the unit costs of all classes of work done by his employees, as compared with that done by the employees of every other district, naturally tends to economical operation, for the superintendent shows his foremen what results are being obtained in other districts, and, especially if they are young men full of life and ambition, they are spurred on to fresh endeavor. The ability of superintendent and foreman to raise the pay of daily men as a reward for increased efficiency, puts everybody in a district practically on a piecework basis, for the monthly men are taught to feel that their salaries will be raised as their costs decrease.

The first cost report sent to the district superintendents in Philadelphia was for January, 1900. By the middle of the year, unit costs were being lowered considerably, and the saving made before 1902 was immense. In that year, due to the hard coal strike, distribution operations, especially the connection of fuel appliances, were on a tremendous scale, but notwithstanding the necessity of hiring many green men, the unit costs for 1902 were appreciably lower than in 1901. Each year since then has shown the value of the report in lowering costs, or in holding

them stationary in the face of advancing wages. The effect of the cost report in each district has been to set all minds at work devising economies. When one district succeeded in lowering a record made by another district, the latter would be spurred on to renewed endeavor. As might be expected after sixteen years of such striving, most of the unit costs are nearly alike in all districts, and any future saving on jobs which involve a definite amount of work, such as main or service laying, meter or appliance work, undoubtedly will be small. The difference, however, between the costs now shown and those of June, 1900, represent yearly a respectable percentage of total distribution expense.

The cost report in use in Philadelphia shows costs for each of the five districts, and also the average cost for the whole system, under the following heads:

Character of Work	Information Given
Mains — 4″, 6″, 8″, 12″	Feet laid, and labor cost per foot (each size).
" 3″, 4″, 6″, 8″, 12″	Feet overhauled, and labor cost per foot (each size).
Services	Average length of each service. Number of new and of renewed services. Cost per foot as between new and renewed services, divided into labor, hauling, paving and material.
Meter Change Work	Number of meters handled. Cost per meter, divided into labor, hauling and material.
New Sets	Number of new sets. Cost per meter, divided into labor and material.
Turn-on and off Work	Number of turn-ons and offs. Cost per job, divided into labor and material.
Meter Testing	Number of meters removed. Labor cost per meter removed, of all testing and meter handling, in district shop, not charged to repair account.
Fuel Appliance Connection Work Lighting Appliance Connection Work	Number of appliances connected, divided into various classes. Cost per appliance connected in each class, divided into labor, material and general expense.

Character of Work	Information Given
Fuel Appliance Maintenance Work Lighting Appliance Maintenance Work Complaint Expense	Number of jobs attended to. Cost per job divided into labor and material.
Housepipe Inspection	Number of final inspections passed. Cost per unit, divided into labor, material and general expense.
Distribution Office Expense	Total number of jobs done. Labor cost per job, obtained by dividing total number in each district into clerical labor charged to this account.

In the above description, the exact name of each account has not been given, similar accounts being grouped under a general head.

The unit shown under "Distribution Office Expense" was the last to be added to the report, but its effect on office practice has been revolutionary, for were the present unit cost to equal that obtaining when the unit was first shown, the account would cost $100,000 more than it does to-day.

The monthly cost reports are supplemented by a yearly report, and this, in turn, by a yearly cost letter, which shows each superintendent (1) a comparison of the most important operations in each district as between the year under review and the previous year; (2) tabulated sets of unit costs for former years, with the average to date; and (3) a list of the superintendents and chief foremen in each district for the two years compared.

CHAPTER X

INSPECTION

General

Of course, each district superintendent and foreman acts as an inspector over the work under his charge, and for street work no other inspection is needed. For the work in consumers' houses, direct supervision of each job is not possible, nor, in general, required. The general foreman of fitters, with his assistants, are supposed to see a sufficient number of jobs to maintain the fitting force at a proper stage of efficiency. Also, as is detailed in Chapter XLIX, a special inspector, reporting to the Superintendent of Meters, visits a certain number of meter jobs. In Philadelphia, to cover other phases of fitting work and of distribution activities to which sufficient attention might not be paid by the district organizations, special men called "inspectors" have been assigned, and their duties will be described under the two headings of "Inspection of Work" and "Inspection of Equipment."

Inspection of Work

Inspector of Accounts

Operating data and unit costs are of value only if correct, and where classification of time and material is being made by separate district organizations, it is important that some one man inspect from time to time the methods in use. Otherwise, no matter how carefully instructions may be written, startling divergencies in practice will arise. The Inspector of Accounts sees to it that there is uniformity in all details of daily and cost reports, studies the duties and efficiency of the district clerical force, interviews other departments in connection with proposed changes in routine, endeavors to keep the various manuals in accord with actual practice, and, in general, keeps a lookout for possible economies in the office work of the department.

Inspector of Appliance Work

When a company begins to handle new lines of appliances, or when, because of high peak loads, a number of green men must be hired to do appliance work, an Inspector of Appliance Work will prove of great value. His sole duty being to educate the fitters in appliance work, and not being burdened, as are the district foremen, with the responsibility of getting the work done on time, the Inspector, by holding evening meetings and by coaching the men on the job (it is wonderful how much territory may be covered and jobs seen in a day by one energetic man on a motorcycle) will bring the entire appliance force to a proper state of efficiency in a far shorter time than would be possible by the use of the district organization only, and there is the added advantage that practice is made more uniform where one man explains the construction, connection, adjustment and repair of new appliances, than where this information is given by a separate man in each district. When the men become coached thoroughly, the Inspector's position may be abolished safely and revived again if the need arises.

Inspection of Equipment

General

Every distribution department possesses a good deal of material which is not in use or under view constantly enough to ensure that its condition is being maintained unimpaired to prevent sudden failure in the case of structures, or to allow instant use in the case of equipment. Periodical inspection of such material is needed, and to insure this, dates for such inspection must be set, and reports required. A table should be prepared, listing every kind of inspection, with date, by whom made, and how reported. A convenient form of report consists of a sheet of letter size, ruled one way for months and the other for equipment. This is sent in each month, initialed by the Superintendent, each inspection being shown by date. After initialing in the Engineer's Office, it is returned to the district for next month's report. At the end of the year, one sheet gives a complete record of all inspections in a district.

Inspector of Equipment

Much of the material inspection, such as tools, exposed mains, service valves, etc., which is made at stated intervals, can be cared for properly by the district organization, but where the

inspection to be of greatest value should be a continuous one, as is preëminently the case where employees are uniformed, and it is desired that a certain standard of cleanness and neatness prevail, then an Inspector of Equipment is well worth while. Such a man, going from district to district, seeing the street men at their work, and the fitting force as they report for duty, can, if inspired with the right spirit, accomplish much more than the proper uniforming of the force. Without acting in any way as a spy, he can keep his eyes open to many things showing differences in practice, and besides informing the Engineer's Office, is in a position to tell each District Superintendent of good ideas observed in other districts. Among the duties which may be assigned to this Inspector are occasional trips with the house-pipe inspectors, the oversight of the repair of service carts and tool wagons, and the inspection of accident and medical kits and of apparatus for use in gaseous atmospheres.

Inspection of Material

Besides the equipment in use, there are certain classes of material which may with profit be inspected either at the point of manufacture or upon receipt at the store room. In the first class falls cast-iron pipe and specials, the inspection of which is spoken of in Chapter XII, also service and other types of brass cocks when bought in large enough quantities. In the second class are included lighting and fuel appliances, and the details of their inspection is given in Chapter LXXXI. Here it only will be said that the work of inspection as well as questions of design could be cared for by an "Inspector of Lighting Appliances" and an "Inspector of Fuel Appliances," both positions often being held by one man. The remainder of distribution material being mostly steel pipe and fittings, requires no systematic inspection.

CHAPTER XI

ACCIDENTS

General Attitude

The subject of accidents is a very broad one, and in a large company should be cared for by a claim department, whose manager will keep abreast of the latest developments and diffuse a proper viewpoint. Wherever possible, the handling of all claims should be kept within the company, as insurance with a casualty company often results in antagonizing all accident victims, whether employees or public.

Be the company large or small, with claim department or not, the distribution head should do all in his power to minimize accidents to his men and to persons or property affected by their work. Given a sympathetic attitude and a willingness to learn from others, good results will follow. There is an increasing volume of "Safety" literature available, and this should be freely resorted to.

Methods of Prevention

Rules

With a century's experience in distributing gas, many advisable precautions have become known. These should be made familiar to each employee by definite rules applying exactly to local conditions. In addition, the thought of accident prevention should be borne in mind throughout all instruction manuals.

Drills

One of the dangers ever present in gas distribution is that of asphyxiation. Each employee should, therefore, be familiar with the details of resuscitation treatment, and to insure this, periodical drills should be required. The benign possibilities of such widespread knowledge among company employees are realized only through experience. The day has passed when

only the street men are supposed to be interested in asphyxiation cases. In winter, every complaint man should be provided with the restoratives for internal use, and through his drills, be competent to induce artificial respiration. (See A and B, Figure 57, page 183.)

Treatment of Accidents

To Employees

Employees should be considered as being in the service of the company from the time they leave home for work until their return. Where the employee has a good record, and the accident is not due to his own gross negligence, at least three-quarter time and the payment of any large sickness expense, should, in the absence of any legal compensation, be allowed during disability. A careful investigation of each accident,and an accident record of each employee, should suffice to avoid "fake" cases and malingering. A record for the various districts, kept by the distribution head, showing accident payments in relation to payroll, will be valuable as disclosing any great differences calling for investigation and justification. This applies to all classes of accidents.

In return for the above generous treatment, the employee should be required, besides promptly reporting any accident, no matter how trivial it may seem, to submit to whatever medical treatment is deemed advisable.

To Outsiders

Where the injury is to a person not in the company's employ, prompt investigation should be followed by necessary attention and settlement, except where the company believes there is no moral or legal liability and large payments are demanded. The disadvantage at which a corporation is placed by a jury trial, as well as the value of a community's good will, afford ample justification for any settlements involving little expense, where the company is not at fault but the individual apparently is honestly convinced to the contrary. As mentioned before, the company should be prepared to treat accidents to outsiders due to inhalation of gas, even though from their own negligence or suicidal intent.

To Property

The same considerations apply to accidents to the property as to the persons of outsiders. Most of these cases are trivial, and

SECTION I

MAINS

CHAPTER XII

MATERIAL

Cast Iron

Cast iron has been, and is still, used almost universally for mains. Upon considering the causes for the universal prevalence of cast-iron mains for gas work, it must be remembered that when the first gas works was built in this country, *wrought iron was not available, and later on, when it began to be made, the price was higher, size for size, than cast iron, and even now, for sizes 6 to 30-inch inclusive, cast iron is cheaper than wrought iron. Therefore, cast iron has had the field to itself, and has, in the main, proved so satisfactory that the engineer who decides to install, on a large scale, wrought iron instead of cast iron, incurs a great responsibility.

First of all, on that most important point, length of life, it is known that cast iron will last indefinitely in good soils, and many years under the worst conditions. While wrought iron has not been used to a sufficient extent, and for a long enough period, on main work to furnish conclusive data as to the number of years that it may be expected to last when protected by a proper coating, enough experience has been gained from coated services to show that great care is necessary in the coating to make reasonably sure an existence of, say, twenty or thirty years. The question as to the best coating and the supervision of its application are responsibilities of no small order.

Second. In towns of 100,000 or over, the present congestion of streets with underground structures causes, in main laying,

* Where the words "wrought iron" occur in this chapter by themselves, they stand also for steel.

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Second. In towns of 100,000 or over, the present congestion of streets with underground structures causes, in main laying,

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many deflections from a straight line, and these make a wrought iron system proportionately very much more expensive and difficult than is the case with cast iron.

Third. The thinness of the wrought iron renders very weak all service connections tapped in the pipe itself. This makes imperative the use of some form of a clip or saddle, and, especially in city work where services may come every 10 feet, another item of considerable cost must be charged against wrought iron. In addition, there is more chance of leakage from this form of connection than from the usual connection to a cast iron main.

In view of the above facts, it is not surprising that cast iron has reigned supreme as the material for gas mains, especially when it is considered that, the large mains excepted, the leakage of a cast iron main system can be made of slight consequence by the use of cement joints.

The only joint for cast iron pipe that has found acceptance in this country is the bell and spigot joint, formerly made up exclusively with cast lead, but now more and more, in small sizes, with cement, and in large sizes with lead wool. The turned and bored joint, though used extensively in England at one time, has never found favor here. Neither have the various types of patent joints, either requiring a special bell or used with the ordinary bell, flourished to any extent. The prejudice for the ordinary bell and spigot joint is explained easily when the records of modern pipe are known, and when, in addition, it is stated that the common, everyday joint is far and away superior to any patent joint in its adaptability to the various conditions of underground work.

It is, of course, important that a bell should be strong enough to resist any splitting strain caused by caulking lead or driving cement. In early days, the point was not always borne in mind by designers, but the present A. G. I. standard provides a bell about whose strength there can be no question.

Wrought Iron and Steel

Wrought iron has never been used to any extent as a material for mains distributing gas under ordinary pressures. The only exception to this is the system of the Standard Gas Light Company of the City of New York, and as since the purchase of the Standard by the Consolidated Company, no more wrought

iron mains have been laid, it is to be presumed that any saving due to small leakage claimed as a result of wrought iron, was not sufficient to overcome the objections to wrought iron mains. The Standard Company experienced great trouble from the breaking of the cast iron branches used, and a large stock of split branches was needed to clamp over the broken ones, in a manner similar to the repair of a broken main by a split sleeve.

The reasons that ordinarily render the use of cast iron preferable to wrought iron have been already spoken of. There are, however, certain conditions arising in ordinary distribution work where wrought iron may sometimes be used to great advantage. In small towns, or the residential suburbs of a large city, — in other words, in any place where the services will never average closer than 50 feet and the probable consumption never exceed the capacity of a 3- or 4-inch main, — a wrought iron main, provided (when laid) with tees for all probable services, furnishes a cheaper, stronger and tighter line than could be obtained from cast iron. The soil in such localities generally is very good, and a well-coated wrought iron pipe has a very good chance of a long life. Another condition favorable to the use of wrought iron is on a hillside where there is rock and the opportunity is afforded of saving the cost of blasting by laying in a water, or a sewer, trench. Cast iron would be sure to leak if laid on such insecure foundation as is afforded by a position part way up in a refilled trench, but wrought iron 3-inch or larger is quite strong enough to stand any settling, while the slope of the hillside prevents serious trapping.

The advantage of a tight line possessed by wrought iron, while not sufficient, as we have seen, to cause its use in ordinary work, does force its adoption for the high-pressure lines, which, since 1898, have been used to convey gas for long distances at pressures ranging up to 50 pounds. On all these lines, none of the disadvantages attaching to the use of wrought iron obtain to any extent, except the question of life, and as a cast iron line could not be made as tight for anything like the same cost, there is no doubt as to the advisability of risking the life.

Just as for very small mains, wrought iron may be preferable to cast iron, because of greater strength, so for very large mains it seemed at one time that steel might be preferable to cast iron because of less cost and danger from breaks. A 30-inch main may be laid for less cost, in both labor and material, if of riveted steel than if of cast iron. It will be perfectly tight and will

never crack. Its advantages over cast iron in lighter weight and cost increase very rapidly with the size of the proposed main. Under ordinary city conditions, cast iron would be chosen as against steel for a 30-inch main, because a pipe of that size would have a line sufficiently crooked to make riveted work intricate enough to throw the balance in favor of cast iron. As the size increases, the great cost and dimensions of any specials make more and more necessary a very straight line even for cast iron, and, therefore, the riveted steel shows up to better advantage. Where it is a question of bringing gas from a works situated on the outskirts, it is quite probable that the line for the main would be a very straight one, and then even for 30-inch, riveted steel would be preferable on that score. An added advantage of steel is that its use furnishes a main which at any time may be converted into a high-pressure feeder. Such a change of pressure applied to a cast-iron main with cast lead joints would mean a good deal of trouble.

In view of the above facts, why does the 60-inch riveted steel pipe, laid ten years or more ago by the Consolidated Gas Company of New York, furnish the only example known to the writer of a large steel main, and why has the same company recently used cast iron for its 72-inch main laid in a tunnel under the East River? Because gas engineers are not satisfied as to the long life of a steel pipe, and its probable shortness of life as compared with cast iron outweighs any of the advantages of steel just detailed. The 60-inch pipe is now in a very bad condition in spots.

Other Material

Wood

In the early days, when cast iron was expensive and hard to procure, hollow logs were used for gas mains, and served the purpose pretty well. In fact, there are probably several places which still have some wood mileage. The difficulty of making tight service connections was a serious drawback to the use of wood. However, as between 2-inch wood and 2-inch cast iron, it is quite probable that the balance stands in favor of the former, because of the latter's liability to breakage.

Fibre

About ten years ago a fibre pipe was tried by a few gas companies, but the saving over cast iron was not great, and con-

densation was found to soften the pipe after some months exposure. In addition, the fibre material was not conducive to tight service connections.

Sewer Pipe

Vitrified clay pipe has been tried to a small extent in Madison, Wisconsin, and Denver, Colorado, and their experience has been unfavorable to its use, notwithstanding a great saving in first cost as compared with cast iron. Many bells were found broken after a year's time, the breaks being attributed to expansion and contraction. Even without such breaks, the difficulty of making a tight service connection, and the greater number of joints in the main itself, would be sufficient to condemn this innovation.

Design of Pipe and Specials

Steel

The use of steel pipe in the ordinary main system is so slight, and the consequent saving in cost to be gained by using any lighter pipe than the ordinary standard is so inconsiderable, that the gas engineer accepts wisely the standard steel pipe as commercially made for water and steam use, knowing that it will be satisfactory for the insignificant pressure used in gas distribution, even though "commercial" steel pipe is often 10 per cent under standard weight. When used for gas, most of the thickness of a steel pipe is useful mainly to give a longer life against corrosion and occasionally to resist external strains.

The ordinary screw joint is used for sizes 6-inch and under. For 8-inch and over, a plain end pipe with a malleable iron or steel sleeve joint, provided with rubber gaskets, is cheaper and usually preferable.

For specials, the commercial malleable, or cast iron, fittings, made for steam work, are used, except for drip pots, whether "line" or "side," and these would be the same as for cast-iron mains. Ordinarily, in steel lines, tees and crosses are the only specials needed, bends being rendered unnecessary by bending the pipe.

Cast Iron

Short History of Past Standards

The first cast iron pipe and specials used in this country were imported from England and undoubtedly varied with each

maker. The first American manufacturers made their patterns presumably from the English product. The first attempt at a standard was made as late as 1890, by the Society of Gas Lighting, and the patterns approved by it were adopted by a few of the eastern manufacturers, and in 1898, with some corrections, by the American Gas Light Association as its standard. It was hoped that the action of this Association would result, after a reasonable time, in a uniformity in pipe and specials. There undoubtedly was some extension of the use of the standard, but as a whole, the gas companies either continued to use any pattern sent by the manufacturer, or, in a few cases, devised a special standard of their own. The justification for such an individual standard lay in the fact that the 1898 standard was open to valid criticism in points of design and also that it was incomplete.

By 1900 it had become apparent that the members of the American Gas Light Association were not adhering to their 1898 standard, yet it was not until 1905 that the American Gas Light Association accepted as its standard, as a revision of the 1898 standard, a set of plates which were thought to represent good practice, and yet were, in a way, a composite of existing standards.

In 1906, the American Gas Light Association merged into the American Gas Institute. The latter could not be asked to accept the 1905 standard, for, in the meantime, many minor errors in it had come to light. In the next five years, several committees were appointed and reported, and finally, in 1911, the Institute adopted drawings for bell and spigot castings based largely on the 1905 standard. This was followed, in 1913, by drawings for flanged castings and by specifications governing the manufacture of all cast iron pipe and specials.

Advantages in the Use of a Standard

Both makers and users of cast iron pipe and specials rapidly are becoming impressed with the economic advantage of having but one standard for all gas work in this country, and as fast as old patterns are worn out they are replaced by ones of standard dimensions. Every user should be sure to specify A. G. I. standard when ordering his castings.

Inspection of Pipe and Specials

The inspection of pipe and specials at the point of manufacture is quite advantageous, as it insures freedom from delay and

trouble due to defective material, these defects usually not being apparent until the material has been laid and sometimes covered over. The cost of foundry inspection is, however, prohibitive to all but the largest gas companies, except where, as may be often the case, the services of an inspector may be secured by the day as needed. There are a number of such pipe inspectors, especially at the eastern pipe foundries, who work by the day for various companies and municipalities. It will pay any company laying over, say, 5 miles of main a year, to make the attempt to have its pipe and specials inspected by such a man.

Whether there is foundry inspection or not, a company should require its material to be made according to the A. G. I. specification. Where there is no foundry inspection, the company generally will lose, rather than gain, in buying of the lowest bidder without regard to individual reputation. Years of foundry inspection have shown that the same kind of inspection means rejection varying from about 2 per cent at the best foundries to 60 per cent, or even more, at the worst. Material not subject to foundry inspection should be examined carefully on receipt.

Stock of Specials

The only justification for the existence of a great variety of special castings, either in a "standard" or in a storeyard, is that the advantage to be gained by the use of a particular design more than compensates for the interest on the increased investment in stock required because of the existence of this particular design. The above statement is based on the fact that, except for large mains and special jobs, a special must be in stock at the time it is required, or else it will not be used, for some other special will be made to do rather than incur great delay.

Fortunately for the small company, a great variety of specials is not an important issue, for usually its mains are not laid in congested territory. The large companies, however, year in and year out, have a chance to use every special that ever was cast, and their officers have a good opportunity to use judgment as to just what specials are in sufficient demand to warrant being always kept in stock. Where the company's territory is large enough to have more than one storeyard in which stocks of specials are kept, the opportunities for an accumulation of dead material are greatly enhanced.

What is needed in this, as in most other problems in life, is exact information. Two or more times during the year, there should be a report made of the stock of each kind of special. This report should be on a special form, and the specials should be shown always in the same order, so that comparison with previous reports is made easy. Once a year the reports should show, in addition to the stock on hand, the number of each kind of special used the previous year. After two or three years of such reports, there will be dependable knowledge as to the number and variety of specials used in any given time, and, therefore, needed presumably in stock, for it must be assumed that the main laying foremen are kept coached properly in the use of specials. The greater the variety of specials kept in stock, the more need for this coaching. Without it, the ordinary foreman forgets about a special that rarely is called for and, therefore, never uses it when the occasion comes.

With allowances for the effect of local conditions, as shown by the record above described, the following general remarks apply to the selection of a stock of specials. In bends, 90° will be used sparingly, $22\frac{1}{2}$° to a somewhat greater extent, but 45° will be in good demand, especially where there are manholes to contend with, and 40 per cent of the 45° bends should be two-bell. An all-spigot bend is sometimes of advantage, but only the largest companies can afford to keep it in stock, and even with them its existence is apt to be forgotten. If there are many streets not at right angles to each other, 60° circle (or radial) bends are useful as affording, by cutting, any lesser angle. Bushings cost little and are very convenient, especially where the size of more of the new pipe laid differs from that of existing pipe to which connection is made. Caps are not as useful as plugs, but should be kept in stock for the two or three sizes of pipe most used, and perhaps one cap of each size in a system.

In crosses and tees, all-bell specials will be found most convenient for almost all new work and preferable as using up spigot pieces of pipe, but some three-bell crosses and two-bell tees should be in stock for use when inserting a branch into an existing line and also for the few occasions in new work where an all-bell special proves inapplicable. In drip pots where, for any reason, many are used to the mile, it will pay to have two capacities for the one or two sizes of mains most used, the small pots being installed where the extent of main drained is short, and the large one in the long stretches. Here, again, without

competent coaching, the main foreman will forget all about the existence of the large pot.

Only the very large companies will have any need for hat flanges, and a small stock in a few sizes will suffice. Plugs are needed in fairly large quantity in some sizes, and every company ought always to keep in stock one or two plugs of every size main in its system. This provision, in connection with the one above spoken of for caps, may prove of value in the case of a sudden necessity for making a gap in a main. A small stock of reducers, some with bell on large end and spigot on small end, and others with bell on small end and spigot on large end, should be in stock, though the bushing will always take the place of the last-mentioned reducer. All-bell or all-spigot reducers are never needed except in very special cases, and may be ordered when wanted.

Sleeves, both solid and split, always are in demand, especially the latter during cold weather, where the amount of 2- and 3-inch pipe is large. It is quite important never to run out of sleeves, and even in the case of mains 16-inch and over, which do not often break, there should be at least one split sleeve of each size always in stock. Of hub sleeves and service sleeves, there should be enough to care for the normal demand for such specials, but a shortage may be met in both cases by inserting a branch.

"Y" branches are, in general, needed only when there are streets making angles of approximately 45° with each other. Where there are only a few such streets, a tee or cross with a 45°, or circle, bend, may be used.

CHAPTER XIII

DESIGN OF MAIN SYSTEM

General Layout

The treatment of the subject matter under this head, as well as "Size of Mains" immediately following, is intended to be suggestive rather than comprehensive. Few, if any, gas engineers have had, or will have in the future, the opportunity of laying out entirely new low-pressure distribution systems of large extent. In practice it always will be found that local conditions of city plan, railroads, water courses, etc., will govern layouts and, to a large extent, prevent any general adoption of a symmetrical plan. Therefore, no attempt is made to describe any layouts. Work of this character should be entrusted only to men of experience, for whom this book is not intended primarily, and whose knowledge will enable them to give their proper relative weight to the many more or less conflicting conditions entering into the design of a distribution system.

A very full treatment of this subject as applied to the reinforcing of the existing main system of a large city, will be found in the paper on "High Pressure Gas Distribution," by J. D. von Maur, published in the 1908 Proceedings of the American Gas Institute.

Size of Mains

Entirely New System

A main system, in order to be deemed satisfactory, must have a small leakage, and contain pipes of size sufficient to insure no excessive pressure variation in the supply to any consumer. Both requirements are met in general by the enlargement of mains. Except perhaps in the congested sections of the very largest cities, given the money, any main system can be brought to a condition approaching the ideal. What the features of such an

ideal condition are will now be discussed, taking, first, the problem presented by the installation of an entirely new system.

"Given a network of mains in a town having no marked differences of elevation, and assuming no consumption or leakage, it would be a simple thing to raise and maintain the same pressure at all points in the mains without regard to the location of the gas works. The whole problem of gas distribution arises from the fact that it is not a question of static pressure, but of keeping up pressures at distant points towards which the gas is flowing, because it is escaping there through gas-consuming appliances; and since the gas will flow through the mains only when the pressure is greater at the point, or points, of entrance than it is at the points of consumption, it is evident that the pressures in the areas near the source, or sources, of supply naturally will be in excess of that in areas which the gas reaches after a longer travel. If the rate of consumption grows to be any appreciable part of the capacity of the pipes, a marked drop in pressure will appear, and the desired uniformity of pressure over the entire network of mains will suffer the more as the rate of consumption encroaches on the capacity." What this drop in pressure should be is like all other elements entering into the problem being considered, — a question of judgment. It will be assumed, except for a small region close to the works, no point in the main system should experience a greater pressure variation than 2 inches. Also, that this will mean that the greatest permissible variation in the pressure at the works outlet will be 2.5 inches. This last figure is based on the idea that during the time of least consumption, the pressures throughout the system will be uniform and that, as the consumption increases up to peak load, a gradual increase of pressure at the works to the extent of 2.5 inches will keep the pressure at the ends of the main system uniform, while the variations at various points nearer the works will not be more than 2 inches, except in the immediate region of the works, which was not to be considered, because as a rule but few consumers would be involved.

For the maximum pressure to be given to any consumer, 6 inches will be taken, and for the minimum 2 inches. These figures represent the views of most gas engineers, with possibly a few voices willing to speak for as high as 8 inches, and arguing that with constancy of pressure, a high pressure is of advantage to the consumer everywhere except only on flat flame burners, which, on the whole, have no excuse for being. Any pressure

lower than 2 inches cannot be considered good service for gas ranges, mantle burners, or any other use of atmospheric flames.*

For the maximum instantaneous demand per consumer, as measured, say, for five minutes during peak load, 20 cubic feet per hour will be taken for the ordinary town, this being equivalent to about 15 cubic feet per maximum hour.

The number of present consumers either is known from a canvass, or can be estimated from the population to be supplied, using a divisor of 4, with the idea that now or later the main system will cover all the houses. In our problem, however, the future consumers are of most importance. What is the expected demand in the future? Another question entirely peculiar to the situation is: For how many year's growth should the proposed system provide? Where the layout of the territory is such that the trunk main feeding from the works is not excessively long before it begins to branch out, a provision for twenty years is preferable to one for a shorter time. For the rate of growth in consumption, or rather in hourly output at peak load, 2 per cent a year is sufficient. This figure is based on the idea that the population will increase $2\frac{1}{2}$ per cent a year and the annual consumption possibly 5 per cent, but because of the increasing use of gas for industrial purposes, the maximum hourly output will each year be a smaller proportion of the daily send out.

Another way of arriving at the future output is to estimate what will be the population, and from this get the yearly output by assuming a sales figure per capita, which, in the case of a town of 10,000, might be put at 2500 cubic feet. [This figure increases with the population, and reaches 9200 cubic feet in New York City.] To convert the yearly output into the maximum day, a divisor from 170 to 300 might be used, and to convert the maximum day to the maximum hour, a divisor from 8 to 10. This method of obtaining the future maximum hourly output appears to involve more chance of error than the method of estimating a percentage increase in what experience has shown will be the present maximum hour.

The area of probable future distribution may, or may not, be hard to estimate. If it should be considered that 10,000 feet will be the distance from the works to the farthest consumer, then from the pressure limitations already assumed, there will be

* In considering these pressures it must be constantly kept in mind that we are discussing the layout of an entirely new system, not the reconstruction or operation of an existing system.

an allowable drop for the 10,000 feet, of 6 inches — 2 inches, or 0.4 inch per thousand lineal feet of main.

The application of the above assumptions to a specific problem would be as follows:

Present population	= 20,000
Growth to provide for	= 20 years
Maximum pressure	= 6 inches
Minimum "	= 2.0 "
Maximum variation in pressure at works	= 2 "
Distance from works to farthest consumer	= 6000 feet
Size of trunk main from works to point of first principal branch connection, 1200 feet distant	= (?)

$$\frac{20000}{4} = 5000 = \text{present consumers.}$$

$5000 \times 20 = 100000$ cubic feet per hour = output at peak load.

$100000(1 + 20 \times .02) = 140000$ cu. ft. per hour = output at peak load 20 years hence.

= delivery trunk main should be designed for.

$$\text{Drop allowable in trunk main} = (6.0 - 2.0) \div \frac{6000}{1200} = 0.8$$

The problem then is: What size main is required to carry 140,000 cubic feet per hour for 1200 feet with a loss of 0.8 inch? A Cox computer, using a specific gravity of .65, and a constant of 1350, shows that a 20-inch main would be needed.

In a similar way, the sizes of the continuation of the trunk main and its principal branch mains may be figured out, although it becomes at times very hard to estimate how large a district, and therefore how much gas, any particular main will be called on to supply. In the case of these secondary mains, as they may be called, it sometimes is more convenient to estimate on a definite area of supply, rather than the number of inhabitants, or consumers. Just how this is done will be explained later on, as also will be the considerations that determine the size of the ordinary mains, viz., those supplying not more than 1000 feet of street.

Existing System

The ordinary conditions calling for the determination of the proper size of a main are, first, where an existing main is insufficient; and second, where an entirely new territory is to be supplied by an extension to the present system. Under the first condition, the new main may, (a) never be called on to supply any output greatly in addition to that now supplied by the existing system, or (b) be so located that it must in the

future supply increased consumption, due to new houses on the present mains and also to extension into new territory. The case (a) is generally limited to built-up portions of a town, where it is thought that the present consumption will show but a slow growth. The size of the new main may be estimated correctly by pressure observations along the main to be replaced. Thus, suppose a 12-inch main, 900 feet long, with no outlet, but feeding at its far end a network of small mains. At the time of peak load, the pressure at the beginning of the 12-inch is 2.3 inches, and at the end 1.5 inches. The use of the computer will show that the main is carrying 45,000 cubic feet per hour. Also that a 16-inch laid in place of the 12-inch will carry the 45,000 cubic feet with a loss of but 0.2 inch, so that, with the given initial pressure of 2.3 inches, the terminal pressure will be 2.1 inches and with 56,000 cubic feet delivery, the terminal pressure would be 2 inches. The case assumed is rather more simple than would occur in practice, for usually the main would be delivering gas at every cross street along its length. If so, the section scale in the computer would come into use. Again, it is not easy always to be sure what effect the change in any one size of main may have in altering the relative deliveries in a interconnected system of mains. Consequently, under most conditions, an error of 0.2 inch or 0.3 inch might occur as between prediction and fulfillment.

In case (b), where the new main will later on supply additional territory, the difficult question often is not only how much will be the ultimate consumption of the territory, but how large will be the territory itself. This determination of respective areas of supply is especially difficult when there is more than one starting point of supply, as in cities with one or more works and holder stations. A determination having been reached, one method of deducing the consumption is as follows, being worked with constants true for Philadelphia. The area of the region determined on, expressed in square feet (obtained by a planimeter if of very irregular shape) is divided by 250,000, and the quotient multiplied by 1550. The result is the number of feet of mains necessary to supply the region, for experience has shown that 1550 feet of main is required to supply every 250,000 square feet. The figure already obtained, divided by 100 and multiplied by 55, will give the maximum hourly consumption of the region in question when built up, for the present maximum hourly output in Philadelphia equals 55 cubic feet per 100 feet of main. The

maximum consumption of the additional territory thus obtained, being added to the existing consumption which must be cared for by the proposed main, its size may be determined easily along the lines laid down in discussing a new system.

The second condition spoken of on the preceeding page, viz., where an entirely new territory is to be supplied by an extension of the present system, is, of course, handled precisely as was the new territory belonging to case (b) just discussed.

In the only cases so far considered in this chapter, the size of the main has been determined entirely with reference to the expected demand on it. If the same principle were applied to every main laid, there would be many streets which a 2- or 3-inch would supply amply. For either size, cast iron is out of the question, because of the structural weakness of such small pipe. As has been mentioned in the chapter on "Material,"(page 53), steel is well adapted for those cases where the soil is good, and where there is almost absolute certainty that a 2- or 3-inch will be large enough for twenty or thirty years to come. The difference in cost between a 2-inch or 3-inch, and a 4-inch is so small, especially under paved streets, that a careless use of these small sizes generally will be more expensive in the long run than a policy of laying nothing less than 4-inch, except after careful consideration. There are certain locations, where, because of physical configuration or lay out of streets, it practically is certain that a small stretch of main will never be extended. This being the case, and the possibilities of consumption along the stretch being pretty well known, there comes the chance for the 2- or 3-inch. The use of such sizes, on streets which are extended block after block until finally what started out as a line 100 feet long has reached 1000, with prospect of still further extension, results in poor service and ultimately increased expense. The advocates of 2-inch mains for towns as large as 100,000, even though such mains are only 400 or 500 feet long and connect at both ends to 4-inch, or larger, have the burden of proof upon them in these days of paved streets and heavy instantaneous demand of gas for water heating, or for industrial purposes.

As stated above, 4-inch is the smallest size to be laid in any town without careful consideration. In cities of 500,000, or over, the policy of laying more 6-inch than 4-inch often is justified, while if the development is that of flats many stories high, 8-inch should be considered frequently. If the development of terri-

tory, and the opening of definite streets, always could be foreseen correctly, the policy of laying mains capable only of caring for, say, 1000 feet of street would be justified, but as development usually does not occur exactly as anticipated, the company in a large city which has used 4-inch very extensively, soon finds itself with a lack of pressure throughout a large territory, and whether this is cured by enlarging mains and maintaining the ordinary system of low pressure distribution, or by special high pressure main feeding into the low pressure network, the cost of this remedial work, with congested conditions and paved streets, generally will make the total investment for the territory in question greater than if a liberal policy in the use of 6-inch mains had been followed. When it is realized that if the cost of a 6-inch main, laid before paving, is called 100, the cost of the same work through asphalt paving is 180, it is very apparent that the small percentage of increase on the total cost represented by the material cost of 6-inch over 4-inch, is apt to prove a cheap insurance from future expense.

Where the ordinary mains are a little larger than their usual demand would require, experience generally will show that the number of sizes of main needed in any system will be few. When 6-inch is the general size used, 8-inch practically will never be needed, and 12-inch only sparingly, for the network of 6-inch mains will be fed by 16- or 20-inch, and they in turn supplied by 24-inch, 30-inch, 36-inch, or even larger. This reduction of the number of sizes in use in a large city is an inevitable result of following out the essentially wise policy, already touched on, of overestimating, rather than underestimating, the size of any main. A point of paramount importance in this connection not yet alluded to, is the limited space available for underground structures, a space which rapidly is proving inadequate to the demands of modern civilization. To lay a 12-inch in place of a 16-inch, a 16-inch in place of a 20-inch, etc., in a street rapidly becoming congested, unless it absolutely is certain that the larger size will never be needed, is a short-sighted policy that will cost dearly in the end. Again, in the outskirts, where underground congestion need not be considered, the same chance of not appreciating how far a territory would develop (spoken of in connection with 2-inch mains) makes wise a liberal policy in regard to feeding mains. A peculiarly aggravated case is where the feeding main is quite long, traversing a tract of undeveloped land to get to a settlement beyond. To lay, say, 15,000 feet of 12-inch under these condi-

tions, and then find in five years that the main is becoming overloaded, is by no means as economical as laying a 16-inch in the first place.

Extension in Advance of Paving

Whether a main should be laid in any street prior to the need for gas, to avoid future disturbance of paving, is, in general, more often a legal or an economic, rather than an engineering, question. When the decision as to the extension rests with the gas company, and the probable data of needed gas supply indicates that the interest on the anticipated investment will be equal to, or less than, the cost of paving, it is good policy to lay the main, selecting as far as possible the location which will involve the shortest future services. Governmental bodies often attach undue importance to the completion of all underground structures prior to paving, losing sight of the many cases where the loss in capital for structures provided but never used, and in interest for all the structures, far exceeds the cost of paving repairs that would be needed if structures were installed only as required. On the other hand, public service companies should not be penny wise and pound foolish as to main extensions.

Location Details

Footway vs. Roadway

The question as to whether a footway or a roadway location is preferable for a main, is one which often is decided by the conditions obtaining for the particular main in question. A few general considerations, however, may be stated. Where services will be needed on one side only, and there will be a main on each side of the street; where both the roadway and footway are very wide; where the roadway would involve greater paving expense than the footway, in all these cases a roadway location requires specific justification. On the other hand, a footway location may possess the following objectionable features, none of which pertain to a roadway location: liability of present or future harm to trees; opposition of householders to disturbance of footway paving, either when laying the main or when searching for leaks later on ; necessity for greater depth when there is but one main, and services are run to opposite side; proximity to house walls, increasing chance for a broken main to deliver enough gas into a house during the night to cause asphyxiation.

Applying these truths to specific cases, a footway location generally is preferable where there is business on one side of the street only, or where there is a main on each side of the street, except where it involves more installation expense, or would bring the main nearer than five feet to the house wall. A roadway location generally is preferable where it will avoid chance of injuring trees, or cement footway paving, and in most cases of only one main on a street. In Philadelphia, where the normal development is that of houses 14 to 18 feet wide, built up in solid rows on streets varying from a total width of 40 feet, with 18 feet from curb to curb, to streets 60 feet, with 34 feet from curb to curb, the street being asphalt, and the footways cement, with perhaps a narrow grass strip at the curb, the roadway location is preferred. The work is done almost invariably before any paving is laid, and usually, because of trees, the grass strip is not available for the main. Therefore, a footway main would involve future disturbance of footway paving in case of leaks, and a greater depth on account of carrying services across the street. This refers to the usual case of one main in the street. Where two mains are laid because of greater width than 60 feet, or because of car tracks, as will be spoken of later, the general policy still is to prefer a roadway location, except for great width, as for instance 80 feet or more, accompanied by 44 feet or more from curb to curb. In such cases, the footways are so wide that a location in the roadway would mean quite a long service, and it generally is possible to so lay in the footway as not to interfere with trees, or to be under much cement paving.

One vs. Two Mains on a Street

Whether there should be one or two mains in any street usually is a question of comparative cost, though occasionally in small towns, where streets have been paved before the advent of gas, no permission will be granted for disturbing the paving either for mains or services, and a main must be laid in each footway. This is not a great hardship often, however, for the saving in the length of services repays a good deal of the cost of the extra main. In cities with a congestion of underground structures, it often is advisable to lay two mains in order to avoid danger to services, due to their crossing over and under many structures, and being exposed to injury every time the street is opened. Also, it often is difficult to find a way across the street without laying so nearly level as to risk future traps. Of course,

the cases where *no* way can be found without a service drip, should of necessity mean two mains, for ordinarily there are too many services to a block to warrant a drip on each service, instead of two mains.

Subject to exceptions, because of individual cases where cost might govern, the Philadelphia practice is to lay one main on streets 70 feet or less in total width, and without car tracks, and two mains on wider streets. With one car track, in congested portions, two mains would be laid on all streets except where the services were not close together; and in the outskirts, on streets 60 feet and over in total width. With two car tracks, two mains always would be laid, except where services were not more than four to every 100 feet of main.

The question of paving, of course, influences the relative cost of one vs. two mains tremendously. The condition most apt to be met with when any paving enters into the problem, is where the street is paved with asphalt and no main has been laid because the development of the land was in doubt. Houses are now being built on both sides of a block 400 feet long, 25 on each side. When the street is 60 feet or more in total width, two footway mains generally will prove cheaper than one main with services crossing the asphalt. Where only one side is being built up, and it is a question what will be the development of the other side, of course, the footway location is to be secured if possible.

Distance In or Out From Curb

There are many advantages in having a standard location, i. e., in always laying a main at a fixed distance from the curb line. There are some towns, it is true, where few curbs are in existence, and distances are measured from the fence line, but these are comparatively few. A fixed location obviates the necessity of furnishing sketches to service gangs, as a knowledge of the side of the street and whether in roadway or footway, is all that is required to uncover the main. Also, the location of street leaks is made easier.

In small towns, the location of the main generally is entirely in the power of the company, and in cities, where location is by permit and as prescribed by local authority, a standard distance generally is assigned to every class of underground structure. Thus, the gas main is located 3 feet 6 inches out from the curb, the water pipe at 4 feet 6 inches, the telephone conduit at 6 feet, the

sewer at 8 feet, and the street railroad conduit at 9 feet, just outside the track. The theory is all right, but in practice two difficulties are encountered, viz., that the available space is not sufficient always for the structures desiring to occupy it, and the theoretical centre lines often are not far enough apart. Also, the water pipe and sewers laid by municipal departments are not so apt to be placed at their standard locations as they should be, for the reason that neither the water nor the sewer department is as amenable to discipline as the private corporations.

The best roadway location for a gas main usually is as close to the curb as possible, because it is advisable that the services cross the fewest number of other structures. This condition is fulfilled by a main close to the curb, for it always must be assumed that if there is only one main in the street, it will be located on the side having the most services. Experience has shown that with a centre line 3 feet, or 3 feet 6 inches out, there is very little chance of any other structure being laid between the main and the curb. A location nearer the curb is undesirable, because when main laying occurs after curbsetting, there would be great danger of the curb settling, and also when laying in a paved street, it generally would be necessary on repaving to remove the thin strip of paving left between the curb and the inside edge of the trench, — quite an additional expense. Three feet six inches will do for mains 12-inch and under, extending to 5 and 6 feet for sizes up to 30-inch. Where a main, generally a large one, is not used for services, the reason for a near-curb location is absent, and one near the centre of the street generally is preferable, for this usually will mean fewer services of all kinds crossing the trench and adding to the laying difficulties. Such mains are so few that there is no objection to deviating from the standard location.

A standard location for a footway main may be difficult to establish because of varying tree locations and widths of footways (both total and paved widths). In Philadelphia, where the total footway width generally is 12 or 13 feet, and the houses are built on the property line, a location of 5 feet inside the curb is acceptable, for it clears any trees, and while usually it runs under the footway paving, this cannot be avoided, for a location under the grass strip would bring tree trouble. The 5-foot location also ensures a fair distance from the house walls. In a town, or the residential portions of a city where there are wide footways and the houses are back from the property line, a

location inside of the paved portion of the footway, say 10 or 12 feet inside the curb, will be preferable, unless because of an inside row of trees.

So far the influence of the proximity of other structures as affecting the location of the gas main, has not been considered. Naturally, it is desirable that a pipe should not settle after it is laid, nor be liable to injury by street openings made for other structures. For protection against future settling, it is necessary to keep as far away as possible from recent trenches of depth greater than that proposed for the gas main. Sewers are usually the only structures whose trenches form any menace, and of course, in many cases the sewer has been laid so long that there is no more settling to be feared. If, however, the sewer has been laid but a few years, it generally is advisable to lay on the opposite side of the street, rather than come nearer than three feet from centre of sewer to centre of main. When there is no sewer, its probable future location should be obtained before deciding on the location for the gas main.

Under city conditions, it often is not possible to be so located that the main will not be more or less uncovered when another structure is repaired, or laid. One of the advantages of a location close to the curb is that it generally is an insurance against interference on the curb side. In laying parallel to a conduit system with frequent manholes, it is, of course, advisable to keep far enough away to clear the manhole walls without deviating from a straight line. Where conditions are so congested that the only available location is over, or under, some structure, if laying over a conduit will give sufficient depth, then even with the necessary deviations for manholes, this should be preferred to a location over a sewer or water pipe, for a solid support may be obtained from the conduit, the chances of its needing repairs are fewer, and the dangers incident to a break in water main, or sewer, are avoided. If there is no chance, except to go under some structure, then lay under the water pipe.

Dead Ends

Connected with the general subject of main locations is the question of "dead ends," or, expressed in another way, under what conditions should mains be laid where no services are required, and the main serves only to close what otherwise would be a gap. Formerly these objections were advanced against a

dead end, — first, it increased the chance of interruption of supply; second, it was apt to be a cause of poor supply; and third, where the use of gas was small, the gas supplied was apt to be of low candle power, as there might be many hours between the time of leaving the works and reaching a burner. With the use of larger street mains and better methods of manufacture, the last two objections to a dead end do not exist, and only the first remains, but under proper distribution organization, any chance of interruption of supply through normal distribution work is rendered negligible, and the danger arising from outside causes is also so slight as not to warrant connecting up the ordinary dead end.

In Philadelphia, the city plan comprises two sets of "principal" streets at right angles to each other, and about 450 feet apart. Through every block thus formed, minor streets may be laid out as suits the owners of the abutting land. Usually two such minor streets are opened, parallel to each other, but in one block they may run north and south and in an adjoining block east and west. This lack of continuity in the minor streets affords many places where to continue a main in a minor street until it joined a main in a principal street, would mean 60 to 100 feet of main passing by the gable end of a house, and not needed for services. Therefore, in minor streets, the Philadelphia practice is to lay the shortest length of main necessary for supply to services, no matter how many dead ends might be caused. This usually means that the mains fed from one end are not longer than 400 feet. Where the minor streets happen to be continuous, and the main extends over two blocks, a dead end would be avoided at the end of the third block if there were no connections at the intersecting principal streets, for otherwise there would be a main about 1400 feet long, fed from one end only, and it would be considered advisable to lay the necessary sixty or one hundred feet to avoid the dead end.

Location of Branches

There is often a chance for a good deal of judgment in the location of branches for mains not immediately needed. This is true especially in Philadelphia, where, as already has been explained, the definite location of minor streets is uncertain until actually opened. In mains under 12-inch, it generally is not advisable to locate branches in this uncertainty. Where the line of

the intersecting street is known, but there is doubt as to how the houses will face, and which side of the street will contain the most houses, and, therefore, other things being equal, should be chosen for the future main, it will not pay to locate the branch in mains under 12-inch unless the street on which the main is being laid is unpaved, and will be paved before the intersecting street is developed. In this case, in order to save paving, a branch should be located, and the proper side line, or lines, extended from it to the limits of the proposed paving. If later on, the side chosen proves inferior to the other side, a crossing should be made, preferably at 45°. Where the street on which the main work is being done is paved, there is, of course, no reason for deciding upon a branch location in an uncertainty.

In mains 12- and 16-inch, the cost of inserting a branch after the pipe is laid, is enough to make it generally worth while to decide as best may be, on the location of all branches as the main is laid. In this case, where there is no paving expense to be saved, the side line would consist of a short bagging piece out of each arm of the branch, in order to make an investment which never may be used, as small as possible. For mains 20-inch and over, the use of hub sleeve, or hat flange, for connecting to branch mains, makes it advisable to omit the branch in most cases of doubt, where paving expense will not be increased.

Where there is a standard distance for the gas main, of course, all branches will be set with reference to this distance. Information should be obtained as to the location of other structures proposed for the intersecting street, and this may prove the deciding factor as to the side chosen.

Experience in Philadelphia shows that the use of tees, as compared to crosses, is about 4 to 1. Of course, a good deal of this is owing to the discontinuity of the minor streets, but it also is true that for the principal streets, tees are more often needed, and it is quite probable that the tendency of the average gang foreman is to lay a cross where two tees would best care for the needs of the intersection.

The foregoing has been written from the standpoint of main extension in a developing territory. When renewing mains, the location of branches generally is determined by existing pipe. If, however, an intersecting pipe is of a size so small that it probably will be replaced later on, and it is not at the standard location, or on the preferable side of the street, then the branch should be located in the line of the proposed new intersecting

main, and connection made to the existing main in the most economical way, this generally involving crossing over at a 45° angle, and laying pipe of a size smaller than the standard size, in order to keep down any investment to be abandoned later on.

Depth

The four reasons for laying mains deeper than would suffice in an unpaved street just to cover them, and in a paved street, to clear the paving, are, first, to enable services to drain into the mains; second, to protect from injury, due to stresses brought about by street traffic; third, to decrease chances of leakage, due to temperature changes; fourth, to avoid other sub-surface structures. The first reason probably could be satisfied in most cases by a depth of two feet, and in latitudes south of Washington, in small towns with no heavy street traffic, such a depth might be made the standard with mains of standard weight, and 4-inch the smallest size. (In every case here mentioned, depth means distance from the top of the main to the street surface).

In cities and large towns, 3 feet is considered the proper depth to satisfy the second and third reasons, and probably is standard practice throughout the country, except in the New England States and those on the northern frontier, where 4 feet or more is the practice of some managers to avoid temperature changes. Unfortunately there is very little data as to just at what point a rise, or fall, in main temperature begins to cause so many broken mains, or leaky joints, as to make the increased cost of greater depth advisable to decrease the temperature range. It is probable that most mains are laid and joints made with the pipe temperature ranging from 60° to 70°. Main temperature records for 11 years in Philadelphia indicate that for normal years, the range is from 30° to 78°. Therefore, the greatest stress comes on the main in the winter, and both for lead and cement joints it would seem to be good policy to keep the pipe temperature while laying under, rather than over 60°. Philadelphia experience has shown that during normal winters, leaky joints and broken mains, in sizes 4-inch and over, are not many, and even in one very cold winter, with the frost line at 30 to 36 inches, instead of the usual 17 to 20 inches, the trouble experienced with mains 4-inch and over, properly laid, would not justify a standard depth of more than 3 feet. In other words, the pipe temperatures at which the Philadelphia mains are laid, seem to be low enough so that a drop to 30° does not set up a stress strong enough to crack the

ordinary sized pipe, or break the cement joint. Main temperature records from cold climates extending over several years, and referring to various depths, together with leaks in mains at various depths, would be of great value to enable some opinion to be formed as to just what minimum temperature justified certain depths, or rather below what minimum temperature, leaks became so frequent as to necessitate a depth secure against such temperature.

Considering pipe 16-inch or over, the amount of such sizes in any one city is comparatively limited, and as the joint, whether of cement or lead, of such pipe when opposed to a contraction stress, seems to be the weakest point, the pipe probably begins to leak under less range of temperature than, say, a 6-inch, where with cement joints, the joint is stronger than the pipe. Hence, considering the cost of finding and stopping leaks in a large pipe, the laying of large mains at a greater depth than 3 feet might in any city of the same, or higher, latitude than Philadelphia be regarded as a wise measure.

The above paragraphs were written prior to 1912. During the first two months of that year, the temperatures east of longitude 105° W. were the lowest for 40 years. In other words, these were the most severe conditions ever experienced by modern gas distribution systems. They resulted generally in an unprecedented number of main and service leaks, severely taxing the physical resources of many companies. An investigation of 36 cities, embracing extremes of population, showed as follows:

1. The broken mains usually were 4-inch or smaller, and with poor foundation.
2. Breaks were most numerous in those cities where the frost line just reached the main.
3. Breaks or leaks were few comparatively where the frost line went decidedly below the main.

Therefore, it is justifiable to conclude that even under extreme conditions, mains 4-inch and larger, with a good foundation, will give little trouble, and that except in such localities where a depth of, say, 4 feet always will be below frost, there is no advantage commensurate with the increased expense, to be gained by laying mains with more than 3 feet cover.

Considering the fourth reason, — the avoidance of other structures, — just how much of a deviation above or below the standard depth should thus be caused, ordinarily is a case for individual judgment. Where the main is small, the cost of

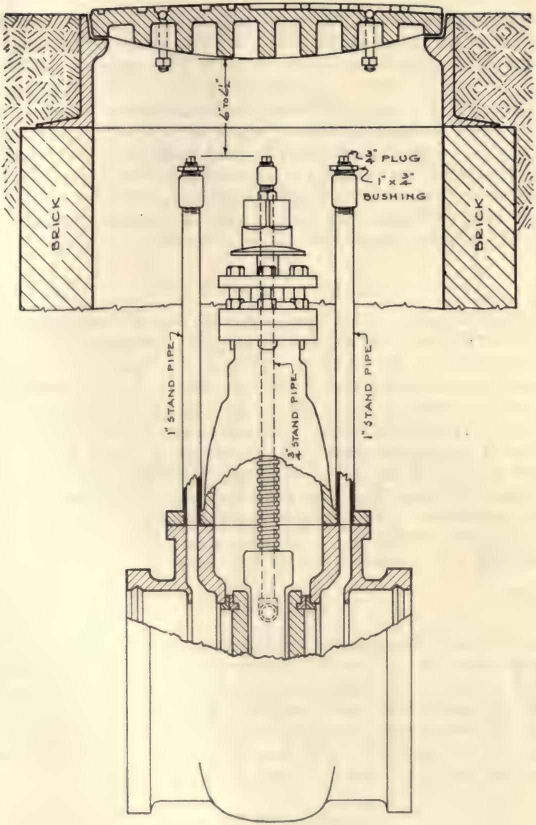
moving the structure usually is not justified if the choice lies between going above or below it. Where the main is large, sewer drains from houses, or street inlets, water services, or any small structures, should be removed rather than to deviate from standard cover by, say, more than 9 inches down or 6 inches up, or than to use specials to make the necessary deviations in line. A small water main, or a connection to a fire hydrant would not be changed except to avoid somewhat more deflection than above considered. For any main, except for comparatively short distances, say, less than 50 feet, 4 feet cover is preferable to 2, 5 feet to 21 inches, and 6 feet to 18 inches.

Valves

Use For Valves

The ordinary distribution pressure obtaining in gas mains makes the shutting off of gas flow by means of stoppers or bags so easy that the universal use of valves at almost every street intersection, following water practice, is not justified, and there probably is only one large city, viz., Boston, where the main system may be valved off in small sections. The only justification for continuing there the installation of valves is that the investment already is so considerable that the comparatively slight annual expense involved is worth while. When, however, the maintenance cost of such a valve system is considered, and the few occasions for its use known, the conclusion seems inevitable that the maintenance of an extensive system of valves is an unjustifiable extravagance. Before the days of fuel use of gas, when there was no reason why the supply should not be shut off during daylight hours, valves were a great convenience in shutting off for repair work, or in testing a section of main for leakage. At the present time, however, gas supply is supposed never to be cut off, except when renewing the service to the consumer in question, and even then there are many occasions when the old service must be kept in use until the new one practically is completed. Therefore, the ordinary street main valve is closed only in times of great emergency, and these occur too seldom and are coped with too successfully by the process of bagging off, to warrant a general use of valves.

There are, however, some locations where valves amply are justified. Such are wherever there is some especial reason to believe an occasion will arise for desiring a speedy shut-off in



VALVE TEST PIPES

Figure 1, page 78.

certain definite locations, as, for instance, on mains leading from holder or manufacturing stations; on branch lines of large size from trunk mains, where such branch line supplies a definite district at points where occasionally need arises to change the direction of gas flow; on large mains crossing trunk sewers, exceeding, say, 8 feet in diameter, especially when such sewers are known to be of poor construction, and liable to collapse during any hard storm; on bridge mains over pieces of water liable to freshets. In the last two locations mentioned, two valves, one on each side of bridge, or sewer, are, of course, needed if the supply of gas may come from either direction.

Type of Valve

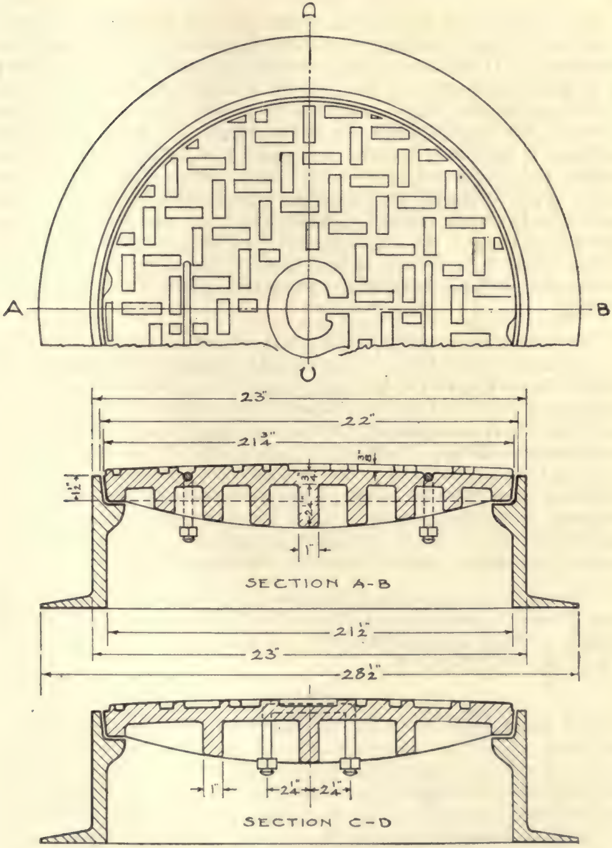
The type of valve to be used preferably is of double-gate construction. Three holes should be tapped in the valve body, and pipes brought to the surface as shown in Figure 1. The hole between the gates affords a chance of testing the tightness of the valve, as a burner attached to the proper standpipe will go out if the valve is perfectly tight. Also, in case a slight leak develops, the central standpipe affords a means of pouring water down between the gates, and thus securing absolute tightness. The holes on each side of the gates afford a chance to observe the difference in pressure conditions occasioned by shutting the valve, while, the valve being open, any one of the three standpipes are available for a pressure record of the main.

Valve Box

There is room for much difference of opinion as to size and design of valve box. The type used in Philadelphia is shown in Figure 2, and was adopted in the belief that it was large enough to allow in most cases, the repacking of the gland, and that the occasion for any other work on a valve would be so rare as not to warrant the expense involved by placing every valve in a manhole large enough to care for every contingency.

Inspection of Valves

In order to ensure its effectiveness in an emergency, every street main valve should be inspected at regular intervals. Once a year is often enough, and summer, or fall before the advent of cold weather, is a good time.



VALVE BOX

Figure 2, page 78.

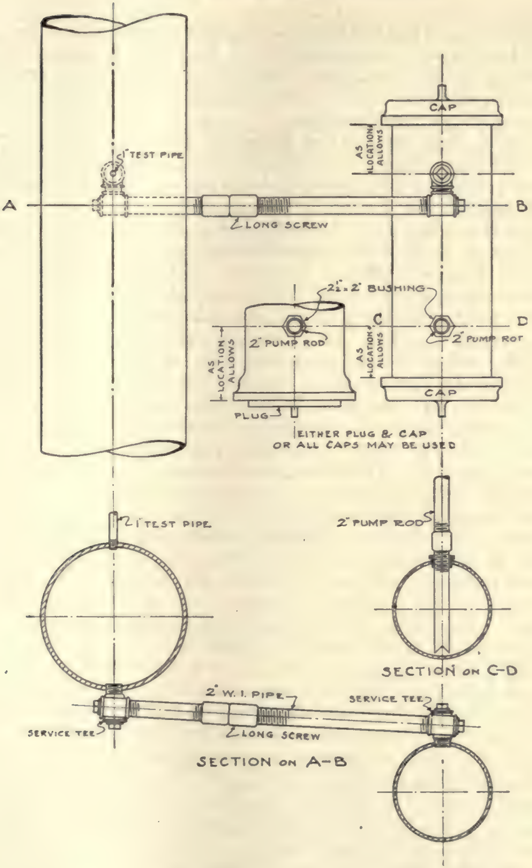
This inspection should be made in the following manner: Remove the nuts holding the stuffing box gland in place and raise the latter. If there is no leak around the stem and the packing is in good condition but dry, apply a little graphite grease on its upper surface, and by means of an oil can, squirt oil dag between the packing and the valve stem. If there is a slight leakage it probably can be stopped by caulking the packing, unless the latter is in poor condition. Any necessary replacement of packing may be made by separating the flax into the individual strands (about $\frac{1}{16}$-inch diameter) and then caulking them into place. An application of oil dag in this as in the former case will ensure lubrication of the stem through and below the packing, beyond the penetrating power of the graphite grease.

The valve stem should be turned in order to make sure that it is not stuck in place. This turning should be through a considerable portion of the whole distance from open to shut, except where not possible because of conditions of gas supply. A valve may be closed one-quarter without affecting pressure in any way, and under ordinary conditions, much further without causing serious loss in pressure. In the case of valves normally shut, whether they may be lifted at all, and if so, off their seats, will depend, in the first instance, upon whether the chance of getting dirt under the seats is too great to warrant moving the valve; and in the second, upon the local conditions of supply.

A good mixture of graphite grease is composed of one part of cup grease to ten parts of Dixon No. 2 flake graphite. The oil dag is a trade preparation, and as used, is diluted with fifteen parts of lubricating oil.

Drips

The great increase in the number of underground structures, brought about by the demands of modern civilization, has resulted in many more drips to the mile than was the case in the early days when the gas main shared the street with the water and the sewer. In many cities, one drip to each intersection in the central sections is quite a general rule. Where grades are fairly steep, drips often may be avoided by laying deep or shallow. The objection to being deep is, of course, the extra cost, and to being shallow, the increased chance of breaks or leaks. Usually it is better to accept the drip and get back to standard grade at



SIDE DRIP POT CONNECTIONS.

Figure 3, page 82.

once than, say, to lay 100 feet of main, with less than 2 feet, or more than 4 feet, cover, to avoid a drip. As will be seen later on, in discussing the maintenance of a main system, by proper organization a drip does not mean any appreciable operating expense if it contains no condensation.

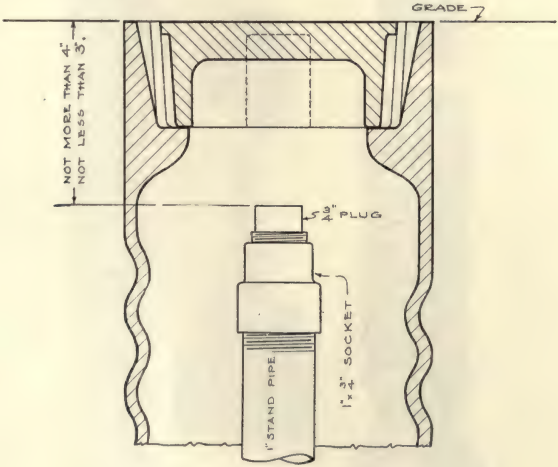
The line drip pot is the preferred form for ordinary use. Where the main in question leads from a holder, or manufacturing station; unless the drip does not drain more than several hundred feet, it generally is a mistake to install the usual line pot, as its capacity is too limited. Instead, a side drip pot formed of pipe, large enough to give the capacity desired, with connections as shown in Figure 3, should be used. The capacity, if possible, should be equal to from 3 to 7 days' condensation at the maximum period. On the ordinary main system, wherever drips drain but small stretches, a line pot of comparatively small capacity is desirable, and with long stretches, a larger pot. The difficulty of ensuring the proper use of two sizes of pots has already been spoken of on page 58, discussing a proper stock of specials.

As in many places the drips will receive practically no condensation, even the use of a shallow pot might be regarded as a waste of material. The alternative, however, would be a standpipe, either straight with a tap through the top of the main, or with a U-shaped bottom terminating in a tap at the bottom of the main. The first arrangement absolutely affords no capacity against an accidental flooding of the main, and the standpipe helps to obstruct gas flow. The second affords little capacity and increases the steel underground,–a sure source of future leakage. Therefore, good practice sticks to line drip pots under ordinary conditions. If, however, a main, 20-inch or larger, had to be trapped for several inches, and this trap drained only a few hundred feet of main, situated a long distance away from a holder, so there was no reason to expect much condensation, the installation of a standpipe through the top of the main in place of a drip pot would not be considered bad practice.

Figure 4 shows the relation of the drip standpipe to the drip box and cover. A straight standpipe is preferable, but if traffic or surface conditions immediately over the drip prevent this, an offset is the alternative. Under country conditions with unpaved roadways, such offset has the advantage of allowing the drip boxes to be more readily found, as when within the curb lines, the box may be raised above the ground level or marked by some stake. When the box is in any roadway great

care should be taken to prevent it resting upon the standpipe, as from this result annoying leaks. The diameter of the standpipe usually is $\frac{3}{4}$-inch or 1-inch, but with power pumping and on drips whose contents are measured in hundreds of gallons, a 2-inch standpipe should be used.

The type of drip box recommended is similar to that used for services and shown in A, Figure 5. The cover should bear the words "Gas Drip."



DRIP BOX & STAND PIPE.

Figure 4, page 82.

In laying mains, head work sometimes will decrease expense due to drip installation. Where a larger main is forced to frequent changes in grade, the condensation often can be carried off to smaller mains at branches, and thus a 6-inch drip pot already installed, or otherwise necessary, be made to care for the condensation from a 12-inch main. Perhaps more frequently the process could be reversed, and one large main made to receive the condensation of several small ones. Again, in growing

territory, where the end of the main just laid is the low point, if it is reasonably certain that within a year or two the main will

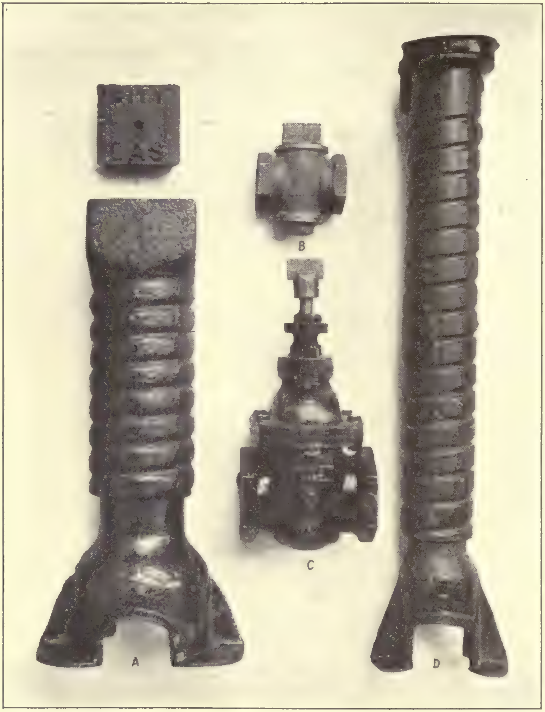


Figure 5—A, Square Stop Box, page 92. B, Service Cock, page 91. C, Service Valve, page 91. D, Round Stop Box, page 92.

be extended, and it is not certain that the grade will have to change at the point just reached, no drip should be installed,

but instead, a hole bored in bottom of cap, or plug, and standpipe attached. The end of the main thus serves as a temporary drip, and not only is interest saved on the drip investment for a year or two, but also the expense of removing the drip when extending the main.

SECTION II

SERVICES

CHAPTER XIV

MATERIAL

Wrought Iron vs. Steel

For many years, wrought iron pipe was used almost exclusively for services. It succeeded to the lead pipe laid in the very early days, to which it was far superior from the standpoint of rigidity and consequent lessened liability to trapping, and than which it soon became much cheaper. In the early nineties, however, the development of the steel industry began to make steel pipe cheaper than wrought iron, and ever since that time, less and less wrought iron pipe has been available for service use. The difficulty of distinguishing between wrought iron and steel has made the substitution of the latter for the former comparatively easy, and the practice has been very common.

As might be expected at the beginning of a new industry, the first steel pipe often was hard in temper and defective in weld. These characteristics, joined with the thread-cutting tools designed for wrought iron, resulted in much annoyance both in the shop and on the street, and, worse than that, in the shape of leaks after services were laid. Therefore, most gas engineers objected to steel, and specified wrought iron, even at a slightly increased cost. As the years went on, the steel pipe became fully as soft, and as well made, as the wrought iron, and the difficulties of thread cutting have now vanished, especially where attention has been paid to the proper design of dies. All the time, however, there has been another objection raised to steel for underground work, viz., its increased liability to corrosion as compared with wrought iron. At first the evidence seemed conclusive enough, but only one side was heard from, and

investigations made by those interested in the use of steel have convinced most people that for service work no one is justified in paying more for wrought iron than for steel. The steel people claim that in the steel pipe made by the Speller process, the metal forming the outer surface of the pipe is treated so that it resists corrosion better than does wrought iron. As an additional reason for the use of steel, results have been published showing a greater resistance to torsional stress than is true of wrought iron.

Preservative Coatings

No reliable data are in existence in regard to the length of life of wrought iron or steel service pipe, whether laid bare or covered with some form of preservative coating. Therefore, the general practice of coating service pipes is not based on any actual knowledge of the added length of life to be expected because of the coating. The cost of the coating is, however, such an inappreciable part of the total cost of installation that there is no justification in laying uncoated pipe.

Almost every manufacturer of a carbon, or asphaltum, paint claims that it is good for service work, but any conclusive test under ordinary conditions would require years of time and the use of the material for thousands of services. Consequently, most tests of special paints have been confined to a few services, or to test pieces buried for several years under aggravated conditions. None of these tests has resulted in the recognition of any one make as the best service coating. In 1875, however, Mr. Andrew Hickenlooper began the use of a home-made coating, which he thought showed its value, and The United Gas Improvement Company has been using it since 1887. So with this record, the coating has been accepted quite widely.

The Hickenlooper mixture is prepared as follows: Bring a kettle of coal tar (20 gallons) to a low boiling point, and add 20 pounds of fresh slaked lime, sifted over the top, and worked down. Boil down to a paste, or a consistency about midway between tar and pitch. Let it settle for a few minutes; then add 4 pounds of tallow and 1 pound of powdered rosin; stir until they are dissolved thoroughly and incorporated with the tar; then let it cool and settle. Ladle off into barrels. When ready for use, to each barrel of 45 gallons of the above mixture, add 4 pounds of crude rubber, dissolved in turpentine to the consistency of thick cream. Heat the mixture to about 100° F., and immerse the service pipe, heated to about the same temperature. Care

should be taken not to exceed the temperature mentioned. If when first prepared, the tar was boiled too long, making the preparation too thick, it should be thinned with kerosene when being heated for use.

An important point to be observed in preparing the coating mixture is to get the rubber dissolved thoroughly, and the dissolved rubber and turpentine of the proper consistency. Use a good grade of crude rubber, free from foreign matter; cut it up into small pieces, and mix it to the proportion of 4 pounds of rubber to 16 gallons of turpentine; this mixture to be worked with a paddle for twenty to thirty minutes daily until the rubber is dissolved thoroughly, which takes from six to eight weeks.

The boiling tank is of $\frac{3}{16}$-inch metal, 6 feet long, 3 feet deep and 3 feet wide, with a removable cover, and four 1 by 36-inch pipe burners, equipped with standard appliance mixers and burner cocks, set crosswise underneath the tank, the gas consumption being 250 cubic feet per hour.

The pipe is cleaned thoroughly by rubbing with ashes, a file being used first where there is much rust or scale. It is heated to about 100° F. through a steam coil, which may be laid on the bottom or attached to the sides of a heating box. This is made of wood, 24 inches wide, 24 inches deep, and 23 feet long. The pipe need not be heated when the temperature outdoors is above 70° F. The mixture is heated also through a steam coil laid in the bottom of the coating trough. This trough is 18 inches wide, 9 inches deep, and the same length as the heating box.

A sloping dripping board is placed between the top of the heating box and the trough, and it is provided with 2-inch hook plates, screwed on perpendicularly, one at each end and one in the centre, on which any excess coating drips off the pipe, the board being placed at a sufficient angle to permit the drip from each length of pipe to fall on the board and run back into the trough.

Hollow wooden caps with handles are used to stop up the pipe when dipping, the operator holding a cap in one hand and a box hook in the other, the latter supporting the weight of pipe. After a thorough immersion of coating, each length is set on the hook plates to drip off.

At this stage the coating drips off very freely, so it is essential to turn each length around two or three times, apply a brush to distribute the coating, and scrape away any excess coating around the hook plates. Almost all the drip re-enters the trough,

and very little coating should be lost on that account. While the pipe is drying, the workmen should engage in cleaning other pipe.

Pipe $2\frac{1}{2}$ inches and over in diameter is not dipped, as there is not enough used to warrant the necessary equipment. It is heated and two coats applied with a brush.

Piling is started when the pipe is wet and still dripping slightly. In taking pipe off the hook plates, a hardwood handle is inserted inside each end of the pipe, and two lengths are carried at a time. Lath is used on the flooring and between each layer of pipe, the soft wood and wet coating being fairly adhesive, so that pipe can be piled to advantage as many as thirty lengths wide and high. It is advisable to start two piles, one for short and one for long pipe.

Coated pipe should be protected from both rain and sunshine, preferably under a shed with one or both ends open to admit air for drying purposes. Threaded ends exposed to the weather should be covered with a sheet of canvas. In piling pipe inside a shed with two sides and back closed, and the front open, elevate the end of pipe at the back of the shed about 3 inches above that at the front or open end of the shed, so that, in the event of rain, the water will not percolate through the inside of pipe, as, if piled level at both ends, or with the pitch the other way, the rain will run through and cause more or less trouble in the form of rust later on.

The coating requires four to six weeks to dry thoroughly on the pipe, according to the weather conditions; in continued damp weather it dries very slowly; therefore, hauling should not be attempted until the pipe is considered in fit condition for use. Skeleton, or open-type, trucks are best adapted for this work, as there is less likelihood of scraping the coating off.

The cost of the coating as done in Philadelphia, on the basis of about a half million feet of $1\frac{1}{4}$-inch pipe a year, is about 0.21 cent per foot for material, and 0.19 cent per foot for labor of cleaning, inspecting and coating.

An investigation in 1903 of over thirty coated services laid in 1898, all of them being in good soil, showed that in the five years the coating had been reduced to the thinnest possible covering, but there practically was no evidence of any corrosion, so that except for the loss of the coating, the pipe was as good as new. A second inspection, in 1908, of 36 services laid in 1898, 21 of which were coated, showed very slight signs of corrosion on 8 of

these coated services. The others, on which corrosion apparently had not yet started, showed almost no trace of coating. In 1913, a third of these periodical inspections was made of 27 services laid in 1898, 26 of these being coated. Of the 27 services examined, 10 showed no corrosion, 10 a slight amount, and 7 showed general corrosion, but in only one case was the depth of this corrosion as much as one thirty-second of an inch.

These investigations lead to the belief that in good soil, coated services may be expected to last certainly from twenty to thirty years, and perhaps much longer. The records in Philadelphia are so arranged that the age of every service laid since 1897 is known, and after thirty or forty years, some valuable information will be possessed.

Whenever there is filled-in ground composed of cinders, slag, ashes or miscellaneous refuse, it is unwise to depend on any coating such as the Hickenlooper. At one time an attempt was made to meet such a situation by the use of a special cement wash, applied with a brush. A good cement film can be obtained, but this is damaged almost invariably by the necessary handling the pipe undergoes in service work, and, therefore, no protection is attained. In many instances pitch and cement have been used as protecting coverings, the pipe being surrounded on the bottom and side by an uncovered square box or V-shaped trough of wood, and the material poured or dropped in. If a good adhesion is obtained between pipe and covering, the service should have a very long life, but there often is difficulty in obtaining this adhesion where cement is used, and therefore, most engineers prefer pitch. The cost of this protection, unless done on a very large scale, probably would be not less than 10 cents per foot, and in some cases of protection with pitch, it has cost 20 cents per foot. However, as there are numerous instances where uncoated services have lasted less than a year in filled ground, these costs are not excessive as compared with the repair of a service under a paved street. During the last year or two, however, the reduced cost of galvanized pipe under normal conditions seems to point the way to the use of this pipe not only in bad fills, but everywhere, in place of coated pipe, for though the excess cost of galvanized over black pipe, of about $1\frac{1}{2}$ cents per foot in the $1\frac{1}{4}$-inch size, exceeds the straight coating costs, there is a saving in handling the galvanized pipe, and also certain incidental savings, which, with the abolition of a central coating plant in

a large situation, point to the gradual universal use of the galvanized pipe.

Stop Cocks

Type of Stop Cock

The value of stop cocks will be discussed later on. Where tney are used, they should, for services 2-inch and smaller, be of the ordinary plug cock type, and either all-brass, or iron body with brass plug. Careful attention should be paid to their design and composition. An ordinary commercial gas cock should be viewed with suspicion for service work, and should be compared with a standard design before being used. Neglect of the above precautions may involve considerable annoyance from leaking and broken curb cocks. A large company should settle upon its own design and metal composition, and inspect the cocks at the place of manufacture, where alone may be obtained proper knowledge of the character of grinding and greasing.

For services $2\frac{1}{2}$-inch and larger, a plug cock is objectionable, because with increase in size, the troubles peculiar to this type of cock are aggravated greatly. Even when all possible care has been exercised in purchase and installation, there will be cases of sticking cocks, which must be dug up to be turned, or, when turned, develop a leak as a result of the strain brought to bear. In the sizes mentioned, the trouble is serious enough to warrant the use of an all-iron double gate valve. (The cost of the gate valve is little, if any, more than a plug cock of the same size.) Of course, the use of both valves and cocks for service work, makes it quite essential that in each particular case, the employee should understand with which he is dealing. In Philadelphia, the letter "V," cast in large size on the stop box cover, indicates that a valve is on the service. An arrow cast on the cover indicates the direction of turning to open the valve.

Where the policy is not to have any stops on services under $1\frac{1}{2}$-inch, it might well be considered whether, for the sake of uniformity in an entirely new system, or the growing sections of an existing system, it would not be good policy to use valves throughout, notwithstanding a slight extra expense.

The type of plug cock used in Philadelphia is shown in B, Figure 5, page 84, and the type of valve in C, Figure 5. It will be noted that instead of the usual square head, the valve is

fitted with a rectangular head. This is made of such dimensions that the same stop key used for the plug cocks will fit the valves.

Location of Stop Cock

A location of the stop cock at a standard distance inside or outside the curb is desirable. In selecting this location, the stop box is the determining factor, the position of the stop cock, and, therefore, of the stop box, being so chosen that the latter, whether in footway or roadway, will be out of the line of travel. The footway is, of course, preferable for the stop cock, as when away from street traffic, a lighter stop box may be used, stop box and stop cock troubles will be lessened, and in snowy regions, boxes will be more accessible in winter. A footway location usually is possible, except where there are vaults extending out to the curb line.

With a roadway main, a roadway location for stop cock should be 18 inches outside the curb, a footway location 15 inches inside the curb, distances being to centre of cock. With a footway main the cock should be out 3 feet from the property line. This distance generally will bring it within the line of the front steps. On very long services to buildings situated far back of the property line, if the standard locations outside the property line are not advisable for any reason, it sometimes is best, for readiness of access, to locate close to the house, even though in so doing there is a violation of the good general rule to follow, viz., to locate the stop cock close to the main.

Stop Boxes

The stop box should be in two pieces, so as to be of adjustable length. It should have a broad base, so it will not readily shift its position, either by settling or tipping over. For roadway situations, the cover should be deep and heavy and well reinforced where the top joins the side walls. A, Figure 5, page 84, shows the type used in Philadelphia for service work (nearly all footway location), as well as drip work (nearly all roadway location). A type of box as shown in D, Figure 5, or else the type now used, but lighter in weight, probably would give excellent service in foot way locations, especially in cement work.

CHAPTER XV

DESIGN OF SERVICE SYSTEM

Conditions Affecting Size of Services

In the old days, when wrought iron was expensive and street work cheap, there was justification in figuring closely upon the size of the service. At present, however, when the difference in cost between a $1\frac{1}{4}$-inch and a $\frac{3}{4}$-inch service, including cock, is only 15 per cent of the total cost of a new $1\frac{1}{4}$-inch service, not including paving, and when the enlargement of a service through paving will add 200 per cent to the original investment, the wise engineer is the one who errs on the high, as compared with the low, side of service size.

For every town, a certain minimum size of service should be determined. In towns of 100,000 or less, 1-inch should be the minimum size, where there is no likelihood of expensive paving, otherwise $1\frac{1}{4}$-inch. In towns of larger population, $1\frac{1}{4}$-inch should be the minimum throughout. The above applies to house services. For street lamp services, 1-inch should be laid, except perhaps where the number was relatively large, and the lamp locations subject to change, in which case $\frac{3}{4}$-inch might be used. Where the minimum house service is 1-inch, this size will be large enough for many houses, and where it is $1\frac{1}{4}$-inch, the number of larger services will be relatively small, except where apartment houses outnumber individual dwellings.

There is room for difference of opinion in preparing a service schedule. Below is given the one in use in Philadelphia.

Size For Fuel and Illumination

	SIZE OF SERVICE
Dwellings of 12 rooms or less	$1\frac{1}{4}''$
" " 13 to 20 rooms	$1\frac{1}{2}''$
" " over 20 rooms and not over 75 outlets	$2''$
Stores, hotels, factories, etc., of 15 outlets or less	$1\frac{1}{4}''$
" " " " " 16 to 30 outlets	$1\frac{1}{2}''$
" " " " " 31 to 75 "	$2''$
" " " " " 76 to 130 "	$2\frac{1}{2}''$

Size For Gas Engine

ENGINE H.P.	SIZE OF SERVICE
Under 5	$1\frac{1}{4}''$
6 to 10	$1\frac{1}{2}''$
11 to 20	$2''$
21 to 40	$2\frac{1}{2}''$

These sizes apply only when engine is supplied through a separate service.

Note. The sizes given apply to services of 100 feet or less in length from main to inside the house wall. For longer services, and for cases where no size is given, the size should be determined in the distribution engineer's office.

Whenever possible, in preference to using the schedule, the maximum hourly gas requirements, in cubic feet, should be determined by counting, at their full-rated consumption, every illuminating and fuel appliance and every outlet and burner, and then using a computer, allowing a loss in pressure of one-tenth of an inch for every 10 yards length of service. The size thus determined always should be at least as large as that shown in the schedule for a building of the size and kind in question. Of course, the service usually is laid before the gas requirements may be known exactly, and therefore, the schedule generally determines the size.

As will be seen from the preceding note, the schedule is based on the idea that there should be no more than one-tenth of an inch loss of pressure in a service at the time of maximum demand, and, in addition, although the average length of the Philadelphia service is only about 28 feet, the schedule is large enough to allow of longer services with no more than one-tenth of an inch drop. The schedule assumes, for instance, that a dwelling of 12 rooms, in common with a store of 15 outlets, will need at some time, gas at the rate of 150 cubic feet per hour. This demand through an $1\frac{1}{4}$-inch service, 100 feet long, will mean a loss of about one-tenth of an inch. Of course, the assumption of such a consumption for the buildings described is more or less arbitrary, but must be considered in the light of the following facts: Working under the above schedule, 97 per cent of all the house services in Philadelphia are $1\frac{1}{4}$-inch; 1.4 per cent are $1\frac{1}{2}$-inch; 1.2 per cent are 2-inch, and four-tenths of 1 per cent are larger than 2-inch. Therefore, the amount to be gained by raising the upper limit of the various sizes is quite negligible, and the schedule as drawn allows, in many cases, ample leeway for the use of instantaneous pressure water heaters and other large gas-consuming appliances, without the expense of service enlargement. Of course, the longer the service, the more important it is that the size be ample to meet probable future requirements, because not only does the

cost of renewal increase with the length, but also the loss in pressure produced by a given percentage increase in demand. Bearing this fact in mind, with the knowledge of the increasing popularity of large gas-consuming appliances, and of what new developments may be expected during the life of the service, it is evident that economy demands a liberal policy in regard to the size of very long services.

Installation in Advance of Paving

In most large cities, the distance from the main to the footway will not average 16 feet. Because of this short distance, and of the many considerations affecting service location as explained hereafter, it is inadvisable, even to save paving, to run services in advance of house erection or definite planning. To speak of only one of the possible complications, a slight variation in the actual, as compared with the proposed, width of the dwellings, would throw out of line, pairs of services intended to lie each side of division walls, and there would result the necessity for re-running, or of offsetting, with many resultant disadvantages. When one side of the street is built up before paving, by laying the main on the opposite side, there will be left only the short services, and this will not involve much paving disturbance.

When services are installed in advance of house erection, the pipe should be run inside the curb as far as the probable location of any future stop cock.

Location Details

House Conditions

The rule commonly followed, and to which there are in Philadelphia only a few exceptions (to be described later), is one separate service to every house. The most serious objection against using one pipe as a common supply for part of its length to two or more houses, is that the fact of common supply may be overlooked, and in case of poor supply to one of the houses, in attempting to clear the service, the supply to the other houses may be interrupted, with the danger of serious consequences. The objection is serious enough, and the economy to be gained, under ordinary city conditions, by making one service serve two houses is too slight to warrant such practice ordinarily. Where, however, the company is comparatively small, so that the employees do not change often, and are familiar with the condi-

tions, it is possible that the danger may be reduced to a point where the practice is warranted if the saving is considerable, as would be the case if the houses are detached, or semi-detached, and located well back from the property line, but not far from each other. In this case, a common pipe would be laid, if possible, along the division line of the pair of semi-detached houses, branching somewhere inside the curb, to go one on each side of the division wall. Where the houses are detached, the common pipe would be laid along a line passing between the houses, and would branch off probably at right angles just back of the front wall line, each branch entering at the side wall. In both instances, if stop cocks are used, they should be placed *after* the service has branched.

In Philadelphia, the cases where one service supplies more than one house are confined to instances of rear buildings, where the supply to the rear building must be through the front one, and to cases of alley runs, where several houses face on a footway possibly not over 4 feet wide. Here a steel pipe from the street main acts as a common supply, the individual services to each house teeing off. When the pipe is laid, a tee is inserted for each house, whether desiring gas or not.

Returning to the case of the separate service, its location is affected by both internal and external features of the house. In rows of houses, to save trenches, it is advisable to lay along the line of the division wall, as thus one trench will serve for a pair of services. At the same time, it is advisable to avoid laying under front steps, across areaways, through piers between cellar windows, or other weak points of the foundation wall, or into coal bins. In any one instance, the location is almost invariably a compromise.

For a very large building with a frontage on two streets having gas mains, a service should be run from each street, if in this way the house piping can be simplified appreciably and its cost much reduced. When only one service is run to such a building, it would, other things being equal, be laid from the street involving the least cost of main and service.

Other Structures

Just as in the case of mains, a location near other structures is not desirable, so also for services is isolation preferable. The great majority of services are laid to new houses during erection,

and in most of these cases, the water service and the sewer connection are laid at about the same time. The water trench is about a foot, and the sewer trench 4 feet or more, deeper than the gas service, so if the latter is close enough to be affected by the inevitable later settlement of these two trenches, both of them possibly carelessly back-filled, there is danger of a trapped, or broken service. Also, of course, if the service is in the trench of either water or sewer pipe, it may be damaged at the time of any opening for their repair. Consequently, isolation is preferred, except when the saving to be gained by sharing the trench is very great. Usually, laying in a sewer trench will be confined to streets where rock exists. Often after the sewer trench has been blasted, there will be opportunity to support the gas service at its proper depth by blocking resting on jutting rock. Otherwise, pieces of pipe may be driven into crevices in the trench side, and the service laid on them, or it may rest on wooden uprights, standing on the sewer itself.

The most frequent case of trench sharing is with the water service, where the distance of house from street is quite long. In Philadelphia, the depth of the water service would be about 3 feet, and this is so little deeper than required for the gas service that there would be no economy in making a ledge in the water ditch for the gas pipe. The practice is to lay the water pipe on the other side of the trench, and thus a separation of perhaps 15 inches is obtained, so that a repair to either will not involve uncovering the other.

Depth

The standard cover over the main fixes in a general way the standard cover for services. With 3 feet over the top of the main, and the service-tee-service-ell connection tapped into the top of the main, the service has 2 feet 8 inches cover at the main. On the same side of the street as the main, this generally will mean 2 feet 6 inches just outside the curb, and a minimum of 2 feet 2 inches under the footway. On the opposite side there will be 2 feet just outside the curb, and a minimum of 1 foot 8 inches under the footway. These figures probably represent the maximum under ordinary conditions. Often, for various reasons, services have less depth, but 18 inches is the minimum permitted to the service cart foreman, and 15 inches the minimum permitted to the district superintendent. Using $1\frac{1}{4}$-inch services, the only disadvantage attaching to shallow depths not involving traffic strains great enough to crush the

pipe, is the question of temperature. If the service is less than 2 feet deep, it is quite probable that in cold weather its temperature is several degrees less than that in the main, and, therefore, the gas loses some candlepower in passing through it. If, however, the meter should be in a location as cold as, or colder than, the service temperature, then, viewed from the standpoint of the effect on the meter diaphragm of the vapors condensed out of the gas, it is an advantage to have a cold service, with the resulting minimum condensation in the meter. With a $1\frac{1}{4}$-inch pipe in the Philadelphia climate, there would be few cases of services closed by frost, even if laid shallow. This being the case, the question might be asked why Philadelphia services are kept deep. One reason is that the universal form of footway paving is artificial cement with a cinder base, and it is essential, for the long life of the pipe, that it be in good soil at a safe distance below this base. Again, the Philadelphia meters contain their own cure against the effect of vapor condensation. Therefore, the advisable course for Philadelphia is to lay services as deep as permitted by main depths.

Service Drips

Only rarely is it impossible to grade the service back to the main. In these few cases there must be a service drip, and the choice lies between a location outside or inside the house. A location inside the house involves three conditions each time the drip is inspected, each one of which should be avoided as much as possible. The first is shutting off the gas supply; the second, opening a pipe in the cellar; and the third, handling condensation within a house. For the above reasons, unless it is considered that the condensation in the service may be ignored, it is preferable to install the drip outside the house, using either of the two styles shown in Figure 6. An inside drip would consist of a piece of pipe about 2 feet long, extending downward from the lower outlet of a cross put on the end of the service, as shown at the right hand of Figure 6.

The drip box used for the outside drips would be the same as that employed for main drips, and described on page 83.

Value of Stop Cocks

Except where required by law, and these instances probably are few, it is believed that the general practice is not to install

curb cocks on services less than 2 inches, or perhaps $1\frac{1}{2}$ inches in diameter. With a curb cock, there is, first, a little more leeway

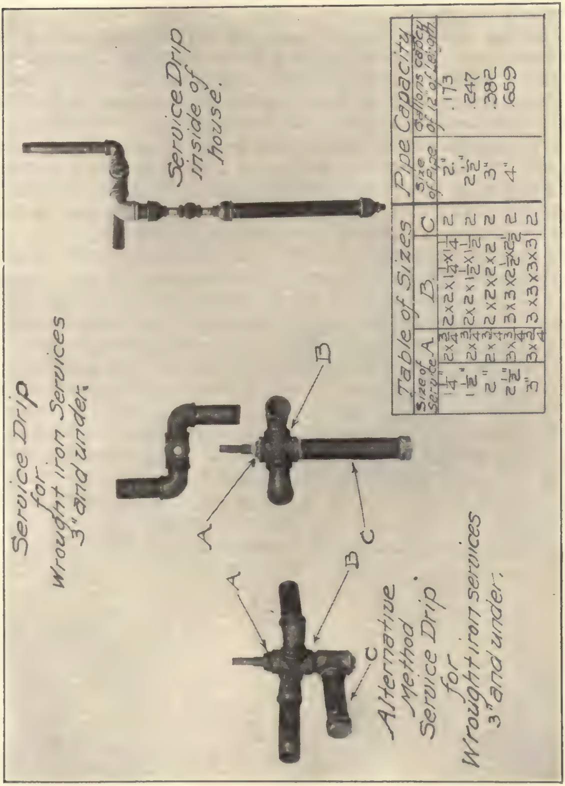


Figure 6—Service Drips. Page 98.

for carelessness in meter work without entailing accidents; second, an occasional opportunity of shutting off gas from a

burning building when the meter could not be reached, or the house end of the service is broken; and third, an opportunity of shutting off the supply to a delinquent consumer without gaining entrance to the building.

Taking up these points in turn, the first is answered by the statement that many companies have adjusted satisfactorily their meter fitting practice on the basis of no curb cock. As to the advantage in case of fire, it generally happens that if the meter is inaccessible, so also is the curb cock, and if conditions do not permit an immediate uncovering and cutting of the service at the main, the only result is the loss of a little gas, with no effect on the spread of the fire. In many cases the cellar is flooded with water, and if there is no curb cock, attention must be paid to adjacent drips to prevent the main being shut off.

Viewed from the standpoint of an aid to summary collection of bills, the curb cock certainly is not worth its cost. It may be used only, of course, where there is but one consumer in a building, and, under city conditions, this is becoming less and less frequent. If entrance to a house is denied, the meter always may be replevined, or the service may be cut off at the main, and in any one year the occasion for such legal or opening expense will be negligible.

It thus appears that a universal use of curb cocks, adding 20 per cent or more to the cost of service installation, and a small per cent to maintenance, is not justified by the resulting advantages.

PART III

EQUIPMENT

Prior to showing how the work of the distribution department is carried out, it will be of advantage to describe, in detail, the various tools used for this work, so that the thread of narration later on will not be interrupted continually by descriptions. If each tool was used for one class of work only, there might be some advantage in describing it while telling how the particular work should be done, but as most of the equipment is used for both main and service installation and maintenance work, there would be either a great repetition of matter, or a reference back to the first job under which the equipment was described. Such being the case, a grouping of all equipment is preferred. Tools common to both street and inside work will be described in company with the equipment used for main and service work.

SECTION I

MAIN AND SERVICE WORK

CHAPTER XVI

TRENCHING AND REFILLING EQUIPMENT

Removing Paving

Asphalt Cutters

Hand

Hand asphalt cutters, D, Figure 7, of the general contractor's pattern, weighing about 12 pounds each and measuring about 20 inches over all, give good results. They are made of medium soft tough steel, and to the end of each arm is spliced a piece of good tool steel about 6 inches long. These steel ends are drawn out with a good thickness of metal to a fairly sharp cutting edge from $2\frac{1}{2}$ to 3 inches wide. A good thickness of metal, carried close to the cutting edge, is very important, as it prevents, to a great extent, pieces of metal from breaking out of the cutting edge. The tool steel ends are tempered carefully, so as to be both hard and tough. Each end of the eye of the cutter should fit the ordinary pick handle.

With good tool steel ends, the cutters can be drawn out and sharpened a number of times before it becomes necessary to re-steel them. Cutters are re-steeled with pieces of tool steel about 6 inches long, until the over-all dimension becomes less than 15 inches, after which it is advisable to scrap them, as by this time the eye will be somewhat round and too large for the ordinary pick handle. The cutter will also be too light in weight to do efficient work. The splicing must be done carefully, and the ends tempered so as to be both hard and tough.

Power

With the advent of power tamping machines, it has become possible to use the tool shown in E, Figure 7. It is made of 5 by $\frac{3}{4}$-inch high-grade tool steel, with a carefully dressed head, having a good striking surface. The cutting point is $3\frac{1}{2}$ inches long, 5 inches wide, and dressed with a rather sharp V-shaped cutting edge, which bevels off $\frac{1}{4}$-inch from center to outer edge. Two $\frac{1}{2}$-inch steel studs are shrunk in holes near the top of the blade, and two $\frac{1}{2}$-inch holes are drilled 1 inch below these studs for bolts to hold the handle, made of $\frac{1}{2}$-inch round iron with a slot at one end, fitting the asphalt blade, and an oval hand hold at the other end. The handle is bent so that the hand hold is about 32 inches higher than the slot.

Asphalt Screen

Canvas screens, Figure 8, are used to protect people and property from flying pieces of asphalt when paving is being cut, and consist

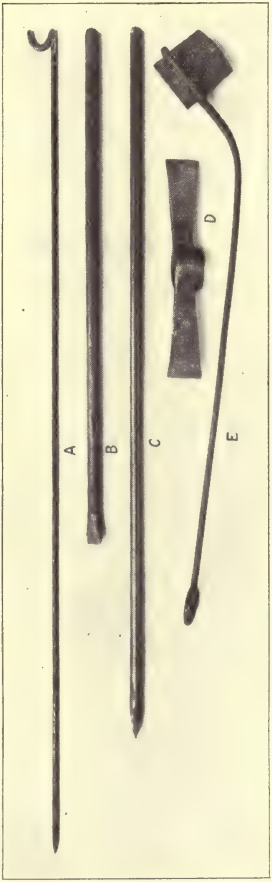


Figure 7. — A, Asphalt Screen Rod, page 105. B, Asphalt Paving Bar, page 105. C, General Paving Bar, page 105. D, Hand Asphalt Cutter, page 103. E, Power Asphalt Cutter, page 104.

of sheets of canvas 5 by 8 feet, with a row of $\frac{5}{8}$-inch brass eyelets spaced 1 foot between centers along the 8-ft. edges.

Asphalt Screen Rod

Asphalt screen rods, A, Figure 7, are used to support asphalt screens, and are made of $\frac{1}{2}$-inch round steel, or iron, 6 feet 4 inches long, with a hook near the top, which fits the $\frac{5}{8}$-inch eyelets in the screen. The bottom of the rod has a sharp point, so that the rod may be driven easily.

Figure 8. — Asphalt Screen, page 104.

Bars

In removing paving, a bar of $1\frac{1}{8}$–inch round steel 5 feet long, should be used. For general work, a diamond point, C, Figure 7, is most useful. For asphalt, a blunt chisel point, B, Figure 7, about $1\frac{1}{2}$ inches wide, often is substituted. The proper tempering of these bars, as well as of any other tempered tools for distribution work, is important and care given to this matter will be repaid amply.

Wedges

Frost and Belgian Block

This wedge, B, Figure 9, is used for removing frozen ground and belgian block after the frost has set them. It is made of

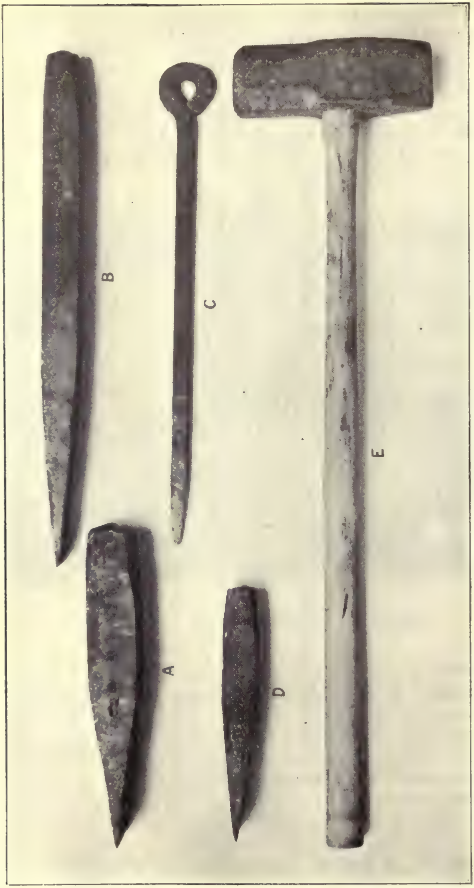


Figure 9. — A, Asphalt Wedge, page 107. B, Frost Wedge, page 105. C. Ditch Line Pin, page 108. D, Rock Wedge, page 107. E, Sledge, page 107.

$1\frac{1}{2}$-inch square steel, $21\frac{1}{2}$ inches long, with a carefully dressed head, having a good striking surface. The wedge point is $8\frac{3}{4}$ inches long and $1\frac{1}{2}$ inches wide, and is dressed with a rather flat V-shaped cutting edge, and rounded to conform with a 4-inch radius. The cutting edge is made rather blunt to prevent parts breaking out, as this wedge is subjected to very rough use. The point must be tempered so as to be hard and very tough.

Rock and Concrete

This wedge, D, Figure 9, is used in wedging out rock and concrete foundations under paving. It is made of $1\frac{1}{2}$-inch square steel, $10\frac{1}{2}$ inches long, with a carefully dressed head, having a good striking surface. The wedge point is 6 inches long and $1\frac{3}{4}$ inches wide, and it is dressed and tempered similar to the frost wedge, with the exception that the cutting wedge is not slightly rounded.

Asphalt

This wedge, A, Figure 9, is used in taking up asphalt after it has been cut. It is made of 2-inch square steel, $12\frac{1}{2}$ inches long, with a carefully dressed head, having a good striking surface. The wedge point is $7\frac{1}{2}$ inches long and 3 inches wide at the cutting edge, and is dressed and tempered similar to the frost wedge, with the exception that the cutting edge is rounded to conform with a 5-inch radius. The width of the wedge is increased to 3 inches at the cutting point, so that it will not chip the asphalt, but will tend to lift large sections.

Sledges

The cast-steel blacksmith's type of sledge, E, Figure 9, is very satisfactory, and the 12-, 14- and 16-pound sizes are best suited for general use. For very heavy work, the 24-pound size frequently is very useful. The handle should be made of tough hickory, 3 feet long.

Trench Marking and Bottoming

Ditch Line

Ditch line is used in marking the line of ditch to be opened, and, in general, the ordinary quality of $\frac{1}{4}$-inch jute rope is satisfactory. For asphalt, heavy cord, chalked and snapped to mark the line, is quite useful.

Ditch Line Pins

Ditch line pins, C, Figure 9, are used to hold the ditch line when it is stretched out. They are made of $\frac{1}{2}$-inch round iron, 15 inches long, pointed at one end, and having an $1\frac{1}{4}$-inch eyelet at the other to aid in driving and pulling the pins.

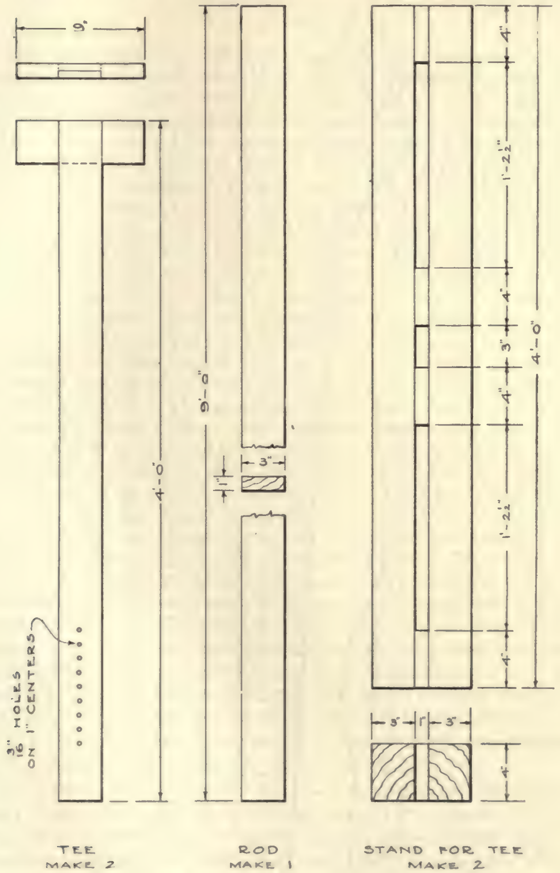
Ditch Targets

Ditch targets are used in digging trenches and setting main blocks, and practically are indispensable where the surface of the ground is uneven.

Non-Adjustable Rod

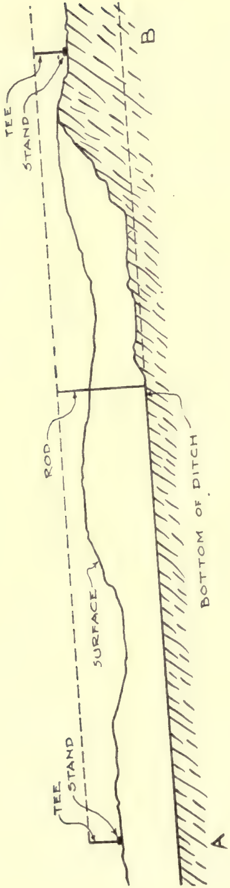
This type, Figure 10, consists of two tees with stands for them, and one levelling rod. The tees are made of 1 by 3-inch planed white pine, 4 feet long, with a cross piece at one end made of the same material, and 9 inches long. A number of $\frac{3}{16}$-inch holes on 1-inch centres are bored in the other end of the tee, which allows the tee to be raised or lowered on the stand. The stand consists of two pieces of 3 by 4-inch hemlock, 4 feet long, separated by four 1-inch distance pieces, one at each end, and two in the centre of the stand placed so as to form a slot 1 by 3 inches. The end of the tee passes through this slot, and is supported by small wire pins passing through the $\frac{3}{16}$-inch holes, the ends of the pins resting on the stand. The levelling rod is made of 1 by 3-inch planed white pine, and for laying small mains at 2 feet 6 inches to 3 feet cover, should be 8 feet long. For large main laying, a greater length will be needed. The cross pieces at the end of the tees are painted red, and one end of the levelling rod white, so as to give greater contrast when sighting between the tees.

Figure 11 illustrates the method of using this type. The depth of trench desired at "A," and also at "B," having been determined, a stand is placed at the side of the trench at each place, and the height of the tees so regulated that the distance from the top of the tee to the desired bottom of the trench is equal to the total length of the rod used. Any point of the trench between "A" and "B" will then be at the right depth when the rod placed on the bottom of the trench at that point, has its top edge in line with the top of the two tees. In other words, the required bottom of trench between "A" and "B" is a straight line parallel to the line of sight over "A" and "B," and, therefore, a tee must be placed at every point of required deviation of trench bottom from a straight line.



DITCH TARGET—NON-ADJUSTABLE ROD

Figure 10, page 108.



METHOD OF USING DITCH TARGET
WITH NON-ADJUSTABLE ROD

Figure 11, page 108.

Adjustable Rod

This type, Figure 12, consists of a sighting level and stand, a target and stand, and a levelling rod. The sighting level consists of a pair of sights mounted one foot apart on a hard wood cross piece, with a small spirit level placed midway between the sights. The cross piece is made of hard wood, 1 inch thick by 1 foot long, and is tapered from a width of $1\frac{3}{4}$ inches at centre to $1\frac{1}{4}$ inches at the ends. This cross piece is clamped to another piece of hard wood, 1 by $2\frac{1}{2}$ by $2\frac{1}{2}$ inches, by a bolt having a thumb nut, so that it can be tightened easily by hand. At the bottom of the 1 by $2\frac{1}{2}$ by $2\frac{1}{2}$-inch piece, is attached, by means of screws, a piece of wrought iron having a $\frac{3}{8}$-inch male thread. To this is attached, by using a $\frac{3}{8}$-inch coupling, a $2\frac{1}{2}$-ft. length of $\frac{3}{8}$-inch steel pipe. This $\frac{3}{8}$-inch pipe slides in a piece of $\frac{3}{4}$-inch steel pipe, 3 feet long, and by means of a thumb-headed set screw in the $\frac{3}{4}$-inch pipe, the sights can be lowered or raised as desired. The end of the $\frac{3}{4}$-inch pipe screws into a $\frac{3}{4}$-inch tee on the cross arm of the stand. The stand is 4 feet wide, and is made of $\frac{3}{4}$-inch nipples and fittings, and has four supporting legs. The target consists of a circular piece of heavy sheet iron, $3\frac{1}{2}$ inches in diameter, attached to a $2\frac{1}{2}$-foot length of $\frac{3}{8}$-inch steel pipe by pipe straps. The $\frac{3}{8}$-inch pipe slides in a 3-foot length of $\frac{3}{4}$-inch steel pipe, and by means of a thumb-headed set screw in the $\frac{3}{4}$-inch pipe, the target can be raised or lowered as desired. The stand is the same as used with the sighting level. The construction of the levelling rod is the same as that of the target, with the exception that a 4-foot length of $\frac{3}{4}$-inch pipe is used with a $\frac{3}{4}$-inch cap on the end. The circular pieces of sheet iron on the levelling rod and target have two quarters painted red and two white, so as to give greater contrast when sighting. One sight has a thin wire supported between two points, and the other a small hole in a brass disc. The sights are held in position by set screws, and can be removed easily when not in use, as they are the only parts which will not stand very rough handling.

This type of target may be used just as is the preceding type, except that both sighting level and target are placed over the trench, and the levelling rod is in a direct line between the two. The adjustable feature of both target and rod, and the ability to move the sighting level in a vertical or horizontal plane, enables this type to be used where the line of trench is not parallel to the line of sight, enables blocks to be set to any grade desired,

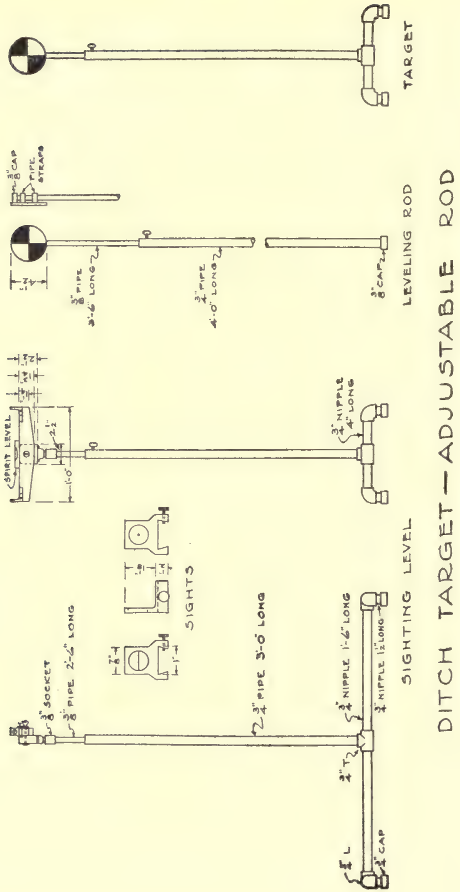


Figure 12. — Ditch Target – Adjustable Rod, page 111.

obviating any use of the hand level on the pipe itself, and affords a means of obtaining relative heights of any underground structures. This type, in short, offers the advantages of a surveyor's level at greatly reduced expense, and is accurate enough for ordinary main work.

Danger Sign

An enameled flag with the word "Danger," and the company's name or initials, or else some advertising cry, such as "Cook with Gas," generally is used to mark the trench by day, and the rod supporting this flag may be made to hold the danger lantern at night. E, Figure 13, shows the danger sign used in Philadelphia.

Red Lantern

The ordinary form of tubular lantern is used, F, Figure 13, and when many are bought, it is advisable to have the company's name stamped in raised letters on the metal work. This may tend to decrease the loss of these lanterns through theft.

Lantern Rods

These rods, D, Figure 13, serve to carry the danger flags as well as the red lanterns. The coil of the loop in which the lantern is hung, is designed to make the stealing of the lantern by a passing wagon more difficult than would be the case if the loop were more open. The rod is of ½-inch round iron, and about 5 feet long over all.

Trench Making

Shovels

The following shovels may be used to advantage:

Sharp nose, hollow back shovel with a D-handle 1¼ inches in diameter and 2 feet 6 inches long, for general trenching work.

Flat nose, hollow back shovel with a D-handle 1¼ inches in diameter and 2 feet 6 inches long, useful in street cleaning, loading dirt or handling material on a flat surface.

Sharp nose, hollow back shovel with a straight handle 1¼ inches in diameter and 4 feet 3 inches long, useful in deep trenching. With some labor, this shovel can be used, in loose soil, to great advantage in ordinary trenching work.

Flat nose, plain back shovel, about 7 inches wide, with a straight handle 1¼ inches in diameter and 4 feet 3 inches long, useful in tunnelling and cutting and removing sod. This shovel frequently is called a tunnelling spade.

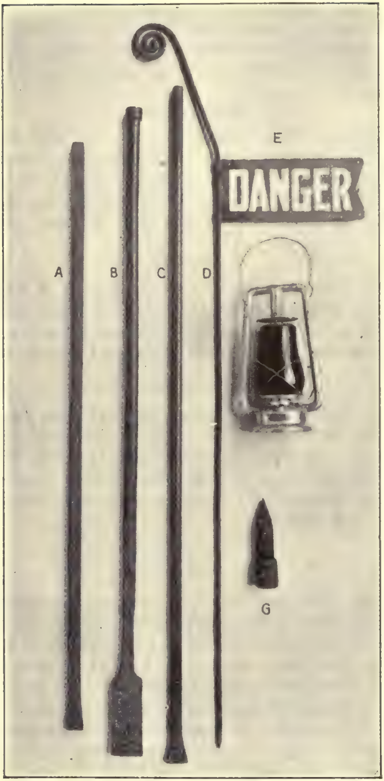


Figure 13.—A, Wall Bar, page 116. B, Pipe Tunnelling Bar, page 115. C, Solid Tunnelling Bar, page 115. D, Lantern Rod, page 113. E, Danger Sign, page 113. F, Red Lantern, page 113. G, Driving Point, page 116.

Picks

Picks of the general railroad or clay pattern, weighing from 8 to 9 pounds each, and measuring from 24 to 28 inches over all, give good results. They are made of soft tough steel, and to the end of each arm is spliced a piece of good tool steel from 4 to 6 inches long. The end of one arm is drawn out to a chisel point $1\frac{1}{4}$ inches wide, and the other end to a fairly sharp point. The tool steel ends of the arms are tempered so as to be both hard and tough. Pick handles are made of tough hickory, 3 feet long.

With good tool-steel ends, the picks can be drawn out and sharpened a number of times before it becomes necessary to re-steel them. Picks are re-steeled with pieces of tool steel about 6 inches long, until the over-all dimension becomes less than 18 inches, after which it is advisable to scrap the pick, as by this time the eye will be somewhat round and too large for the ordinary pickhandle. The splicing must be done carefully, and the points tempered so as to be both hard and tough.

Grub Hoe or Mattock

This tool has a hoe as one arm and a cutter as the other, and is used mostly to cut roots. It is made of steel, weighs about 6 pounds, and has an eye which fits the ordinary pick handle. The cutting arm is at right angles with the hoe arm. The cutting arm is 6 inches long and $3\frac{1}{2}$ inches wide at the cutting edge, and the hoe arm is $8\frac{1}{2}$ inches long and $4\frac{1}{2}$ inches wide at the cutting edge.

Tunnelling Bars

Solid Tunnelling

This bar, C, Figure 13, is made of $1\frac{1}{8}$-inch round steel, 5 feet long, with a blade drawn out at one end 3 inches long, and $2\frac{1}{2}$ inches wide at point. The blade is tempered so as to be tough and hard. This is a heavy bar, and is useful especially in hard or frozen ground.

Pipe Tunnelling

This bar, B, Figure 13, consists of a blade and a pipe handle. The blade is made of steel, 5 inches long and 3 inches wide, with a $\frac{3}{4}$-inch shank, 4 inches long at one end, having a male thread. The 1-inch steel handle is attached to the blade by an ordinary 1 by $\frac{3}{4}$-inch reducing coupling. The end of the blade is tempered. This is a light bar, especially useful in soft soil, and

by varying the lengths of the handle, can be adapted to conditions where space is limited.

Wall

These bars, A, Figure 13, are used in breaking holes through cellar walls in service work, and are made of 1⅛-inch octagonal steel, in lengths 2 feet 6 inches, 3 feet 6 inches and 4 feet 6 inches. The heads are dressed to good striking surfaces, and the chisel points are 3 inches long by 1⅛ inches wide, and are tempered so as to be both hard and tough.

Driving Point

A driving point for service work, G, Figure 13, has a long sharp point, and is made of round steel bar or of heavy steel pipe. The blunt end has a male thread, and the over-all length is about 15 inches. The diameter is the same as that of the service pipe to be driven.

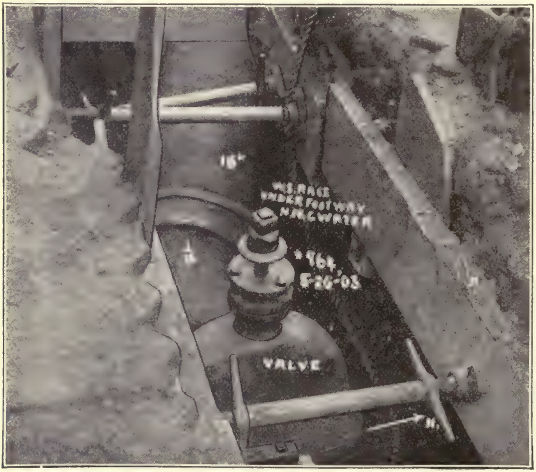


Figure 14.—Shoring Jacks, page 117.

Ditch Shoring Jacks

These jacks, Figure 14, are used in shoring up ditches and in supporting underground structures. The jacks are made of a piece of 1½-inch steel pipe, of different lengths to suit varying conditions, a jack part and a head, both of which fit loosely into the ends of the pipe. The jack part is made of 1½-inch round wrought iron bar, with square screw threads, about 9 inches long, having a heavy wrought iron nut with two arms about 5 inches long, and a loosely attached foot, having a bearing surface of about 6 by 2½ inches. The head consists of 1½-inch wrought iron bar, about 5 inches long, loosely attached to a foot similar to that used with the jack part. The expansion of the complete jack is obtained by turning the nut of the jack part against the end of the steel pipe. If conditions

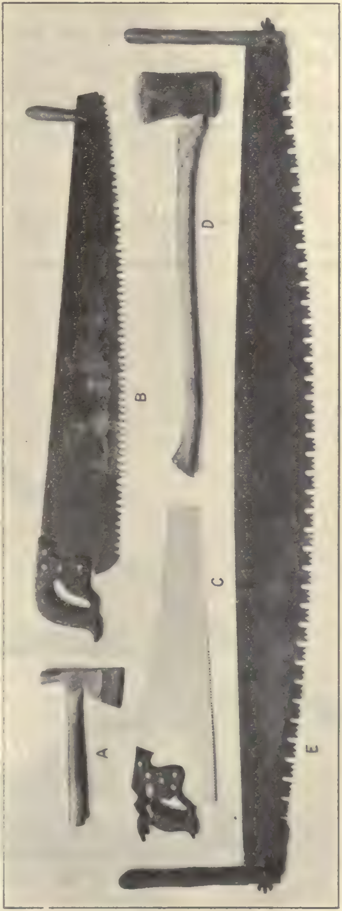


Figure 15.—A, Hatchet, page 118. B, One-Man Crosscut Saw, page 119. C, Hand Rip Saw, page 119. D, Axe, page 118. E, Two-Man Crosscut Saw, page 119.

demand it, a jack part may be used in both ends of the steel pipe, thus getting expansion at two points.

AXE

This Yankee three-quarter, or miner's handle, axe, D, Figure 15, has a cutting edge $4\frac{1}{2}$ inches wide, a handle 28 inches long, and weighs 3 pounds, including handle. The handle is made of tough hickory.

HATCHET

The derrick type hatchet, A, Figure 15, has a cutting edge $3\frac{1}{2}$ inches wide, a handle 13 inches long, and weighs 2 pounds, including handle. The handle is made of tough hickory.

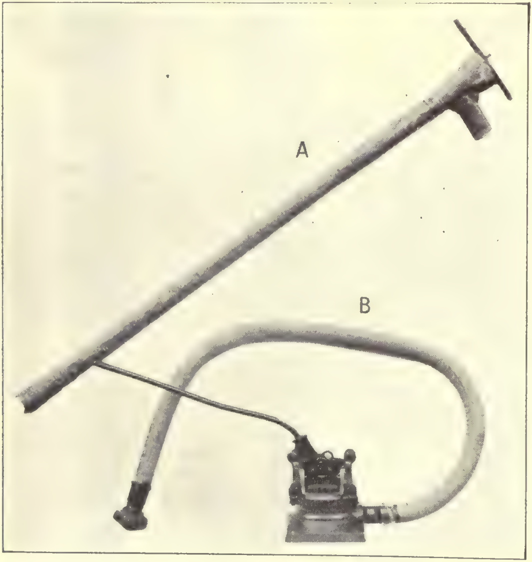


Figure 16—A, Cellar Pump, page 119. B, Block Pump, page 119.

Saws

Hand Rip

This saw, C, Figure 15, is the ordinary carpenter's rip saw, and has a blade 26 inches long.

One-Man Crosscut

This saw, B, Figure 15, is provided with substantial handles. The 3½-foot length is best suited for general use.

Two-Man Crosscut

This saw, E, Figure 15, has two substantial handles, and the 6-foot length is best suited for general use.

Ditch Pumps

Cellar Pump

The ordinary galvanized sheet iron cellar pump, A, Figure 16, about 12 feet long and 4 inches in diameter, is very useful in pumping water out of ordinary ditches where there is very little sediment.

Block Pump

This pump, B, Figure 16, is for deep trenches, and especially where there is a great amount of sediment, as it is almost impossible to choke it. The water is lifted by a rubber diaphragm, which eliminates any friction, and the valves are solid castings and can be removed easily and replaced by hand. Diaphragms are made of para rubber. The suction to the pump is 3 inches diameter, and different lengths of wired hose should be kept on hand for use as conditions require. The pump, when in use, is bolted to heavy planks. The handle should be long enough for two-man operation.

Power Pumps

Power pumps in various forms are available, and will prove economical where large quantities of water must be handled. The most common types are the block pump and the centrifugal pump, both driven by a gasoline engine.

Rock Excavation

Drills

Striking

These drills, C, Figure 17, are made of $1\frac{1}{4}$-inch octagonal steel, with ordinary wing drill point, and range in length from a starting drill, 2 feet 6 inches long, to a following drill, 7 feet long. The heads are dressed to a good striking surface. The wing point of the starting drill is about $2\frac{1}{4}$ inches wide, and the wing point of a following drill always is slightly narrower than the point it follows, to prevent drills from sticking.

Churn

These drills, F, Figure 17, are for soft rock, no striking hammer being necessary. They are made of 1-inch round steel, 7 feet long, with an ordinary wing point at each end, 2 inches wide. All drill points are tempered very hard and tough.

Small compressor outfits are available for driving one nonrotating drill. Every company having much rock work should own one or more of these outfits.

Spoon or cleaner

This tool, B, Figure 17, is used in cleaning out holes during drilling and before placing explosive charges. It is made of $\frac{3}{8}$-inch round steel, 5 feet long, with a spoon form at each end. Another form of cleaner consists of 5 feet of $\frac{1}{2}$-inch steel pipe.

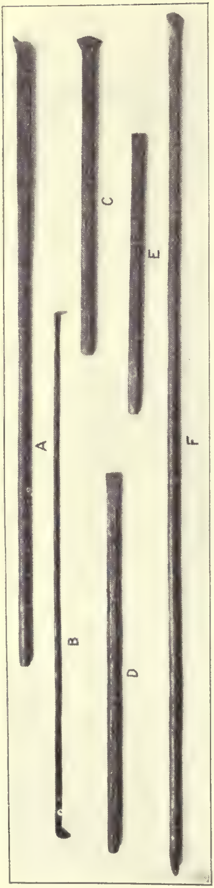


Figure 17.—A, Pinch Bar, page 121. B. Rock Spoon, page 120. C, Striking Drill, page 120. D, Chisel Bar, page 121. E, Short Chisel Bar, page 121. F, Churn Drill, page 120.

Bars

Pinch

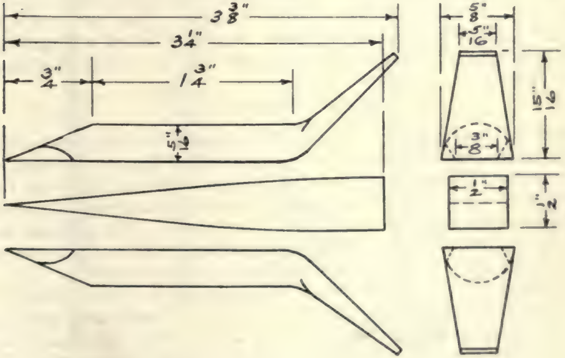
This bar, A, Figure 17, is used in prying out heavy rock, and is made of 1¼-inch square steel for 16 inches from the point, its cross section then changing to 1¼-inch octagonal steel for 12 inches, and from this point to the end of the bar (a distance of 2 feet 8 inches) the cross section is round, and tapers from a diameter of 1¼ inches to 1 inch. The end of the bar is cut off at an angle of 30°, and then turned up about a quarter of an inch, making a heavy blunt point 1¼ inches wide and somewhat like the ordinary wedge point. The bar measures 5 feet over all, and has a tempered point.

Chisel

This bar, D, Figure 17, is used in wedging out heavy rock, and it differs from the pinch bar only in its point, which is a wedge 3½ inches long and 1¼ inches wide.

Short Chisel

This bar, E, Figure 17, is used with striking hammers, and is



STONE PLUG AND FEATHERS.

Figure 18, page 122.

made of $1\frac{1}{4}$-inch octagonal steel about 2 feet 3 inches long, with a chisel point $2\frac{1}{2}$ inches long and $1\frac{1}{4}$ inches wide. The head has a good striking surface, and the point is tempered.

Stone Plugs and Feathers

These tools, Figure 18, are used in splitting rock and for breaking out bottom portions of curb stones. The feathers are made of $\frac{5}{8}$-inch half-round steel, about $3\frac{1}{2}$ inches long, and the plug is wedge-shaped, $\frac{1}{2}$-inch square at base, and $3\frac{1}{4}$ inches long. In drilling the holes for the plugs and feathers, a $\frac{3}{4}$-inch octagonal steel drill, 12 inches long, is used.

Striking Hammer

This hammer, D, Figure 19, is used in rock drilling, cutting large pipe, etc. It should be good cast steel, double-faced, and weighing 8 pounds. The handle should be of tough hickory, 3 feet long.

Stone Sledges

The ordinary commercial stone sledges, C, Figure 19, having a flat face at one end and a rather long V-shaped point at the other end, are best adapted for stone work. They are made in different sizes, but the 16-, 18- and 24-pound sizes will answer for all purposes. The handles should be of tough hickory, 3 feet long.

Blasting Machine

Blasting machines, E, Figure 19, should be of substantial construction, and enclosed in a strong wooden box, to be carried about easily. There are a number of blasting machines on the market which give good results, and the size of machine depends on the number of holes required at one time. For general use in main and service work, a machine which will fire from one to thirty holes at one time, will be found large enough.

The old style safety fuse should never be used. Rock blasting by electricity is acknowledged to be the most effectual, and for economy, safety and certainty of action, supersedes any other system. By exploding a number of holes simultaneously, the united strength of the explosion is utilized at the same instant, thus obtaining at least 10 per cent more execution from the explosive than if the holes were fired independently with the old style safety fuse.

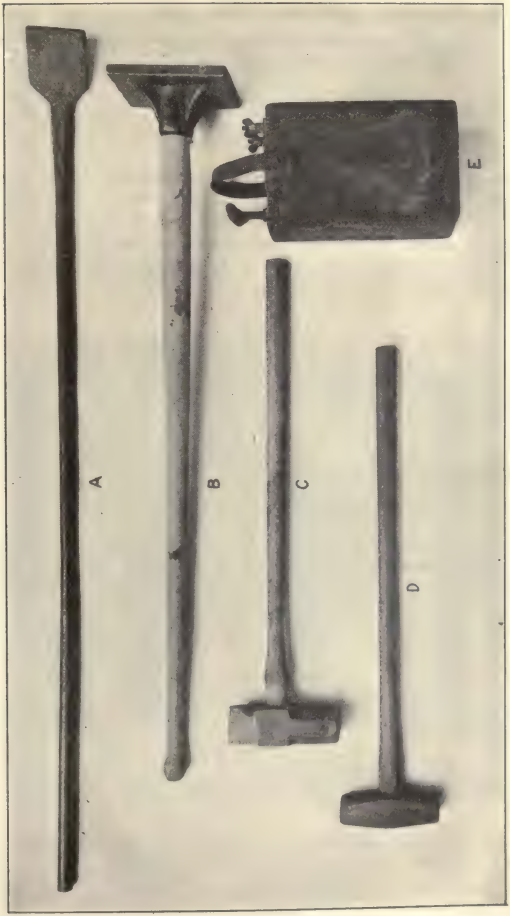


Figure 19.—A, Tamping Bar, page 124. B, Hand Rammer, page 124. C, Stone Sledge, page 122. D, Striking Hammer, page 122. E, Blasting Machine, page 122.

Blasting Mat

A blasting mat is preferable to logs chained together, if the occasion for its use would be frequent.

Refilling and Repaving

Tamping Bar

This bar, A, Figure 19, is used in tamping back earth under mains, and is of the general railroad type. The end of the bar consists of a piece of wrought iron, 4 by 4 by $\frac{3}{4}$-inch, with a $\frac{3}{4}$-inch shank about 12 inches long, bent at a small angle. To this is welded a length of $\frac{3}{4}$-inch steel pipe, making the over-all length about 5 feet 6 inches.

Rammer

This tool, B, Figure 19, consists of an iron casting with a $1\frac{1}{4}$-inch circular hole in the top for the handle. The handles are made of 1-inch steel pipe, or $1\frac{1}{4}$-inch hickory, and are about 4 feet long. The rammer is manufactured in different sizes, but the one having a face 6 inches square and weighing about 20 pounds, is best adapted for general use.

Sundry Equipment

The other equipment required in refilling and paving consists of such standard articles that there is no necessity for describing them. In considering repaving work, a list of the necessary equipment will be given in Chapter XXVI.

CHAPTER XVII

LAYING EQUIPMENT

Cleaning, Laying and Testing

Brushes

Pipe

Pipe brushes are used in cleaning out the lengths of pipe before laying. This is necessary, especially where the pipe has

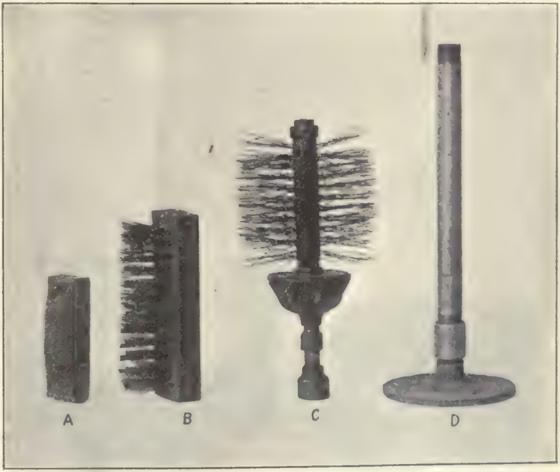


Figure 20.—A, Carding Cloth Brush, page 127. B, Foundry Brush, page 127. C, Small Circular Brush, page 126. D, Pipe Cleaner, page 127.

been strung for some time. The brushes for 3-, 4- and 6-inch pipe consist, C, Figure 20, of a 1-inch heavy wrought iron tube about 6 inches long, cut in two longitudinally, and having a number of small holes which hold the flat steel wire bristles of the brush. The two sections of the tube are held together by clamps and a long screw passing through the centre of the tube. A $\frac{3}{8}$-inch socket is provided at one end for attaching a handle. For large sizes of pipe, up to 16-inch inclusive, the brushes, A, Figure 21, consist of a large circular piece of wood about 10 inches long, with rattan or stiff fibre bristles about 2 inches long. A 1-inch hole is bored through the wood centre of the brush for attaching the handle. Pipe over 16 inches in diameter is cleaned by men crawling into the pipe, and using brooms and wire brushes.

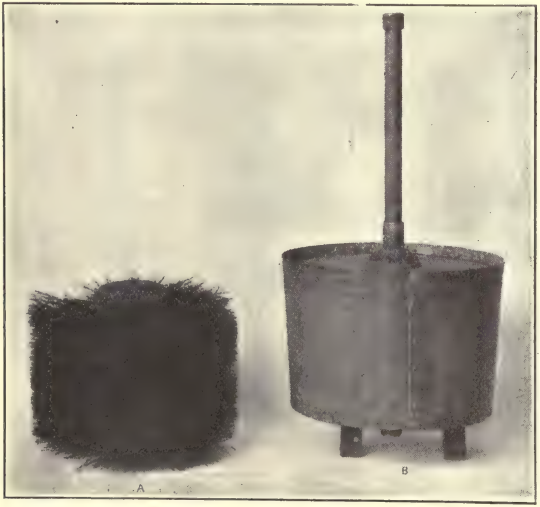


Figure 21.—A, Large Circular Brush, page 126.
B, Metal Plug, page 134.

Wire

These brushes are used in removing rust and scale from bell and spigot ends of pipe, and one type, B, Figure 20, consists of the ordinary foundry brush, having a tough wood back, $7\frac{1}{2}$ by $2\frac{1}{2}$ inches, and flat steel wire bristles or prongs 4 inches long. Worn-out carding cloth, which may be obtained from cotton or woolen mills, nailed to a soft wood backing about 7 inches long, A, Figure 20, makes very good brushes for removing rust and scale from large bells for cement joint making. The brushes may be made concave, or convex, to fit the pipe.

Cleaner

Pipe is cleaned also by a disc, D, Figure 20, made out of heavy sheet iron, slightly smaller in diameter than the pipe to be cleaned. A $\frac{3}{8}$-inch socket attaches the handle to the centre of the disc.

Porters

Pipe porters are used to facilitate the handling of pipe on the street and in the ditch, and are made of oak or hickory in two sizes. The small porter, used in handling small sizes of pipe, is 5 feet long. One end of the porter, for a distance of 2 feet 6 inches, has a rectangular cross section 3 by $2\frac{1}{2}$ inches, with the corners rounded off, and from this point to the end of the handle the cross section is circular and tapers to a diameter of $1\frac{1}{2}$ inches at the end. The large porter, used in handling large sizes of pipe, is 9 feet 6 inches long, and is similar to the small porter. The rectangular cross section is $4\frac{1}{2}$ by $3\frac{1}{2}$ inches and 3 feet 6 inches long, and the handle tapers to a diameter of 2 inches at the end.

Pipe Rope

The 1-inch ordinary commercial manila rope, of good quality, will be found adequate for handling all sizes of pipe where it is not necessary to use a derrick.

Skids

Pipe skids should be made of well-seasoned, straight-grained oak, with one end cut at an angle so that the pipe can be more easily rolled on. For cross section and length, the table below should be followed:

Size of Pipe	Section	Length
16″	2″ x 12″	5′ 2″
20″	6″ x 6″	5′ 6″
24″	6″ x 6″	6′ 0″
30″	6″ x 6″	6′ 6″
36″	8″ x 8″	8′ 0″
48″	8″ x 8″	8′ 0″

Pipe Slings

Pipe slings should be made of a good quality of hemp rope, very carefully spliced. For size and length of rope, the table below should be followed:

Size of Pipe	Size of Rope	Length of Rope	
		Before Splicing	After Splicing
16″	$1\frac{1}{4}$″	13′ 0″	11′ 0″
20″	$1\frac{1}{2}$″	15′ 0″	13′ 0″
24″	$1\frac{1}{2}$″	17′ 6″	15′ 6″
30″	$1\frac{1}{2}$″	20′ 6″	18′ 6″
36″	2″	25′ 6″	23′ 0″
48″	2″	33′ 0″	30′ 0″

Derricks

The ordinary ditch derrick, with four legs and of good substantial construction, is very well adapted for large main laying. The legs are made of strong tough lumber, 4 by 4 inches and 12 feet long, with wrought iron bands on the ends to prevent splitting. The legs are held together at the top by a heavy wrought iron pin, and the bottom of the legs should be so constructed that spikes or wheels can be used. The legs are chained together to prevent spreading.

The winch is attached rigidly to the legs, and has a drum about 6 inches in diameter, and is provided with a band brake, ratchet and stop, to insure safety in operation. Strong single and double tackle blocks are used, and for laying mains 30 inches in diameter, 80 feet of $1\frac{1}{4}$-inch good quality hemp rope is needed. Figure 22 shows the wooden derrick used in Philadelphia. As these derricks wear out, they are being replaced in steel.

For 36-inch and 48-inch mains, the steel derrick shown in Figure 23 has proven very satisfactory. It is patterned after the wooden derrick in use for smaller pipe, and is constructed entirely of steel. The legs are 4-inch I-beams, weighing $9\frac{1}{2}$ pounds per foot, so arranged in pairs that one pair is rigid on one side of the ditch and one pair on the other. Each pair is braced securely

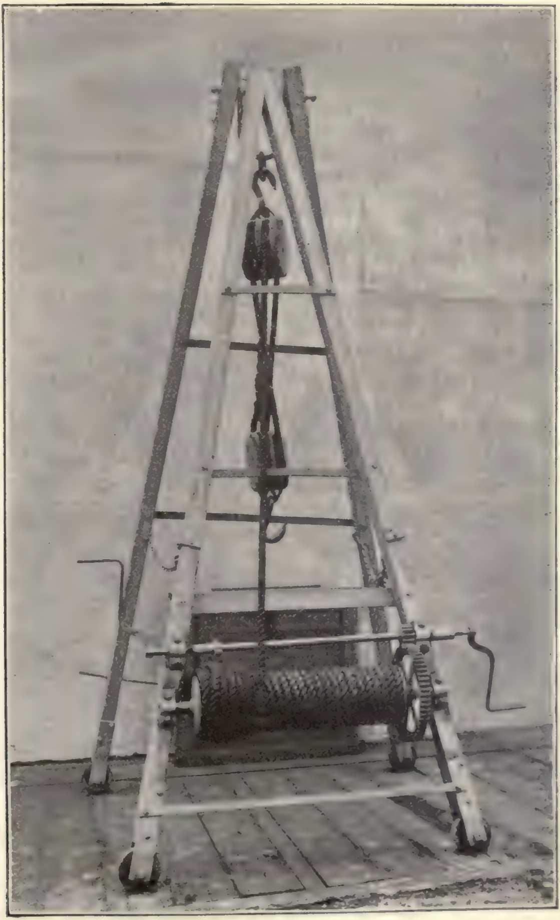


Figure 22.—Wooden Derrick, page 128.

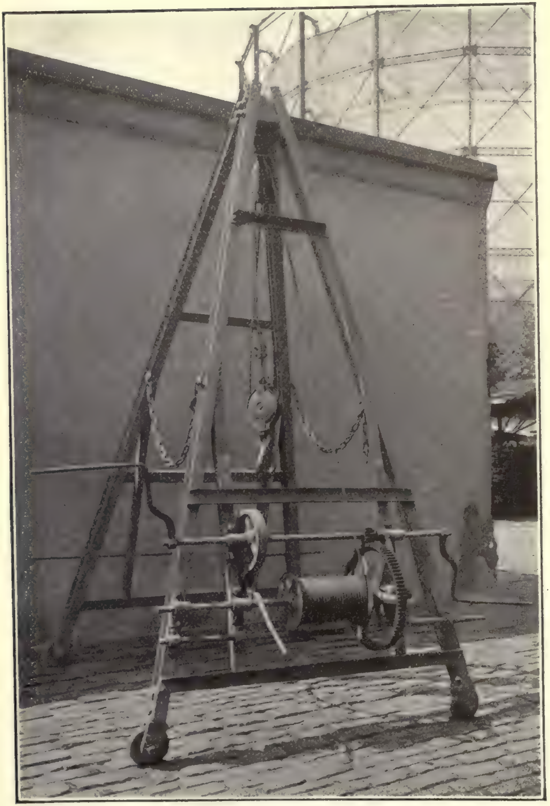


Figure 23.—Steel Derrick, page 128.

with angle and channel iron, and the legs are held together at the top with a $1\frac{3}{8}$-inch hinge pin. The bottoms of the legs are furnished with wheels, and the legs are chained together across the ditch to prevent undue spreading. The winch is attached to the legs, and has a drum 10 inches in diameter, provided with a band brake, ratchet and stop to insure safety in operation. Single and double steel tackle blocks are used, strung with about 120 feet of half-inch wire cable.

Steel derricks should be well protected with a good coating of paint; all bearings should be well oiled, and when a steel cable is used, it should be covered with a good quality graphite grease. In storing these derricks, they should be under cover.

Pipe Levels

Small Pocket

This is a small level, mounted in a cast-iron frame, about 3 inches long, and is convenient for the use of service men, foremen and inspectors.

Small Hand

The ordinary machinist's level, with square ends, top and end plates and low cut side view, is satisfactory. This level is manufactured in different lengths, but the 18- and 24-inch lengths are best suited for main and service work.

Large Hand

This is a long level similar to the machinist's level, with two lugs on the bottom near the ends to enable the bottom of the level to clear the pipe cell. This level is manufactured in different lengths, but the 6-foot length is best suited for main laying.

Bag

Each size main requires its own size bag. These bags, E, Figure 24, are made of good quality of elastic rubber with tubes for inflation, and the large bags are provided with stop cocks at the ends of the tubes. Large bags, made of rubber and covered with canvas, frequently are useful. As rubber deteriorates quickly with age, bags should be ordered in small quantities only. Bags in stock should be kept in a comparatively cool location, out of sunlight, with free ventilation, and not exposed to radiation from steam pipes or acid fumes. It is preferable to move them about, rather than keep them packed up for several months in one box or package.

Figure 24. — A, Stopper, page 133. B, Service Plug, page 134. C, Expansion Plug, page 134. D, Bag Pump, page 135. E, Rubber Bag, page 131. F, Bag Fork, page 133.

Bag Fork

A bag fork, F, Figure 24, is used to insert the bag and hold it in position while inflating. It is made in the shape of a two-prong fork of one length of $\frac{3}{16}$-inch wire, so the only joint is at the top of the handle. The size shown is large enough for 8-inch bags.

Stopper

A stopper consists of a flexible frame, covered with leather, which can be expanded to a circular shape. To this covering is attached carefully a circular piece of oiled canvas. The leather covering makes a tight joint between the frame and the pipe, and the oiled canvas bags off the main.

The stopper is much safer than a bag for stopping the flow of gas, as the danger of sudden collapse is absent. It lasts longer, and, therefore, economy demands that stoppers be used wherever possible, and bags be restricted to cases where, because of conditions peculiar to any pipe, such as faulty casting, or presence of sediment, the section is not truly circular, and the stopper will not fit closely enough to prevent all gas flow. The type shown in A, Figure 24, has given good satisfaction.

Temporary Plugs

Plugs of a more or less temporary nature are needed on many occasions during main and large service work. Several types may be used to advantage.

Wooden

These are turned, cone-shaped, and with dimensions about as follows:

Size of Pipe	Diameter		Length
	Small End	Large End	
3″	$2\frac{7}{16}$″	$3\frac{9}{16}$″	$8\frac{1}{2}$″
4″	$3\frac{7}{16}$″	$4\frac{5}{8}$″	9″
6″	$5\frac{3}{8}$″	$6\frac{7}{8}$″	$9\frac{1}{2}$″
8″	7″	9″	$12\frac{1}{2}$″
10″	9″	$11\frac{1}{4}$″	14″
12″	$10\frac{3}{4}$″	$13\frac{1}{2}$″	14″
16″	$13\frac{3}{4}$″	18″	22″
20″	18″	22″	24″

If used for pipe larger than 12-inch, they should be built up of several pieces; otherwise, they are apt to check so badly as to become worthless.

A wooden plug is very useful, either as a loose stopper to

prevent dirt, water or any other material from entering a line being laid, or, by the help of soap or clay and with previous soaking in water, as a gas-tight stopper, good for days or weeks of service.

Metal

For sizes larger than 12-inch, a wooden plug is quite expensive, and each year the difficulty of getting seasoned wood increases; so in Philadelphia it is now the practice to use a plug, B, Figure 21, (see page 126) made of galvanized sheet iron. It serves as a loose stopper only; for the fit obtained in the pipe is not close enough for work against gas pressure, even though the plug were braced. Dimensions are as follows:

Size of Pipe	Diameter		Length
	Small End	At Flange	
12″	11¼″	12¾″	11″
16″	15¼″	16¾″	11″
20″	19¼″	20¾″	11″
24″	23¼″	24¾″	11″
30″	29¼″	30¾″	11″
36″	35¼″	36¾″	11″
48″	47¼″	48¾″	11″

Expansion

This plug, C, Figure 24, is made in sizes from 6 to 30 inches, although, under ordinary conditions, the larger sizes are not economical because of the ease with which a temporary cement joint may be made with an iron plug. It consists of a cast iron base, with a rubber gasket around the outer edge, which engages with the inside surface of the pipe. It is so constructed that the large wing nut on its outer end, when tightened, forces the rubber gasket against the pipe, forming a gas-tight joint. The wing nut revolves upon a piece of steel pipe through the centre of the plug. This pipe is bent at right angles at its outer end, and is fitted with a cap, which can be removed when purging small mains.

Service

This plug, B, Figure 24, consists of a cone-shaped piece of solid rubber, whose upper diameter is slightly less than the opening in the top of a service tee, and whose lower diameter is slightly less than the inside diameter of the tee. A substantial wire handle, about 6 inches long, is fastened securely through the center of the rubber plug.

Pumps

Bag

This pump, D, Figure 24, used for the inflation of large bags, is similar to the ordinary hand air pump, but much heavier. The cylinder is $10\frac{1}{4}$ inches long, $3\frac{1}{4}$ inches in diameter, and has a heavy base provided with lugs, by which the pump is bolted rigidly to a $1\frac{1}{8}$-inch board, 9 by 14 inches. The suction and discharge passages at the bottom of the pump are both $\frac{1}{2}$-inch,

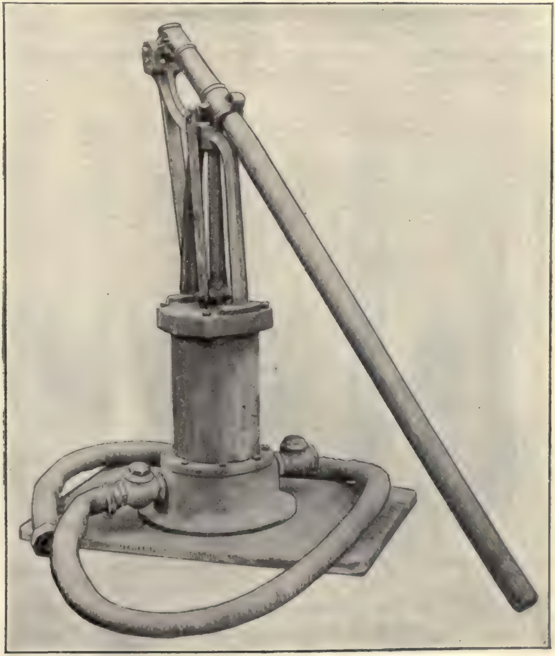


Figure 25. — Main Pump, page 136.

and are combined in one fitting. The discharge passage is provided with a check valve, so that no air can get back from the bag on the suction stroke. A 6-foot length of $\frac{3}{4}$-inch rubber hose is attached to the outlet by a union connection. All metal parts are made of brass with the exception of the steel piston rod.

Main

This is used to pump air into mains to test joints and pipe for leakage. It should be fairly heavy and of substantial construction, so as to stand rough usage and exposure. Gould's direct-acting pump, Figure 25, having an 8-inch cylinder, 12-inch stroke and $1\frac{1}{2}$-inch inlet and outlet connections, with check valves, has given good results. It has a capacity of .34 cubic feet of free air per stroke, is bolted rigidly to a heavy plank platform,

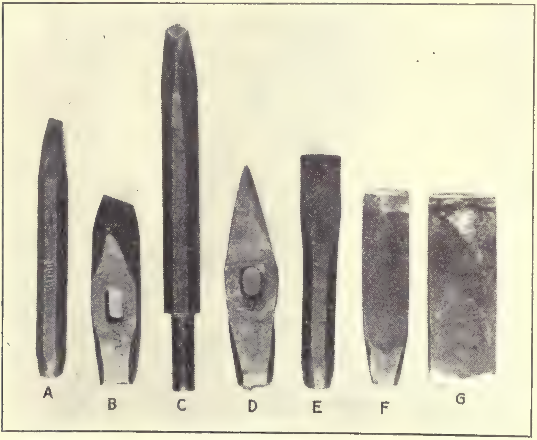


Figure 26. — A, Hand Diamond Point, page 137. B, Handle Diamond Point, page 137. C, Power Diamond Point, page 137. D, Dog Chisel, page 137. E, Cold Chisel, page 137. F, Pipe Bursting Wedge, page 138. G, Pipe Bursting Wedge, page 138.

and may have two strong wooden handles, often made of porters about 5 feet long, enabling four men to work at one time. When a very high pressure test is wanted, or the line capacity is great, a power pump may be needed.

Cutting, Threading and Other Tools

Diamond Points

Hand

This tool, A, Figure 26, is used for gouging cast iron pipe and specials, is made of $\frac{7}{8}$-inch octagonal tool steel about 8 inches long, and one end is dressed with a "diamond face," at an angle of almost 75° with the axis of the tool. The head is dressed carefully, and the diamond-face point is tempered hard and tough.

Handle

This tool, B, Figure 26, differs from the hand tool in being slightly heavier, having a good striking head and a substantial shank provided with an eye to fit the ordinary small hammer handle.

Power

The power tool, C, Figure 26, is a hand diamond point, with an over-all length of 12 inches, and a shank to fit the pneumatic hammer used.

Chisels

Dog

This tool, D, Figure 26, is used in cutting cast iron pipe, and is made of $1\frac{1}{2}$-inch square steel, about 6 inches long, with a cutting edge about $1\frac{1}{2}$ inches wide. It is similar to a small wedge, and has a rather blunt wedge point 3 inches long, and an eye which fits the ordinary hammer handle. The cutting edge is parallel with the length of the handle. The head is dressed carefully, and the wedge point is tempered hard and tough.

Cold

This tool, E, Figure 26, is made of 1-inch octagonal tool steel, 6 to 8 inches long, with a carefully dressed head and rather sharp V-shaped cutting edge, 1 inch wide and 3 inches long. The cutting edge should be tempered so as to be both hard and tough.

Pipe Bursting Wedges

These tools, F and G, Figure 26, are used in cracking pipe after it has been gouged, and are made of good tool steel in two sizes: a 2-inch wedge for large pipe and a $1\frac{3}{8}$-inch wedge for small pipe. The heads are dressed carefully, and the wedge is not tempered.

Pipe Cutters

Pipe cutters should be of substantial construction, but, at the same time, as light as possible, and with few and easily renewable parts. The following cutters are useful for different lines of work:

Roller

One cutting wheel and two rollers in two sizes, — No. 1 for pipe up to $1\frac{1}{4}$-inch inclusive, and No. 2 up to 2-inch inclusive.

Wheel

Three cutting wheels in three sizes,—No. 1 for pipe up to 1-inch inclusive, No. 2 up to 2-inch inclusive, and No. 3 for $2\frac{1}{2}$- and 3-inch.

Large

There are a number of large pipe cutters on the market which can be used to cut either cast or steel pipe. The Anderson type, B, Figure 27, has given very satisfactory service. It consists of a series of links connected by means of claw holds, and carrying cutter wheels, which form a chain, the length of which can be varied to suit the circumference of the various sizes of pipe. This adjustment to any length within the range of the cutter is easily made by hand. A frame, containing a screw-operated yoke, provides the means of tightening the links and wheels. The cutting operation is similar to that of a three-wheel pipe cutter. The cutter comes in two sizes: the No. 1 cuts pipe from 2- to 6-inch, the No. 2 from 4- to 12-inch, and the No. 3 from 10- to 24-inch. Where a stretch of cast-iron main is to be removed and it is not convenient to burn or cut out the joints, the use of a cutter of this type is generally preferable to gouging or breaking the pipe in front of each bell.

Pipe Stocks

Solid

This stock, A, Figure 27, should be of substantial construction, but not too heavy or clumsy, and should be made of malleable iron. The handles should be of round hollow steel, with a male thread at one end for attachment to the stock, and the latter should be so made that dies and guides can be changed easily. Two sizes will be found useful, — one threading pipe up to 1-inch in diameter, and another for $1\frac{1}{2}$- and 2-inch pipe.

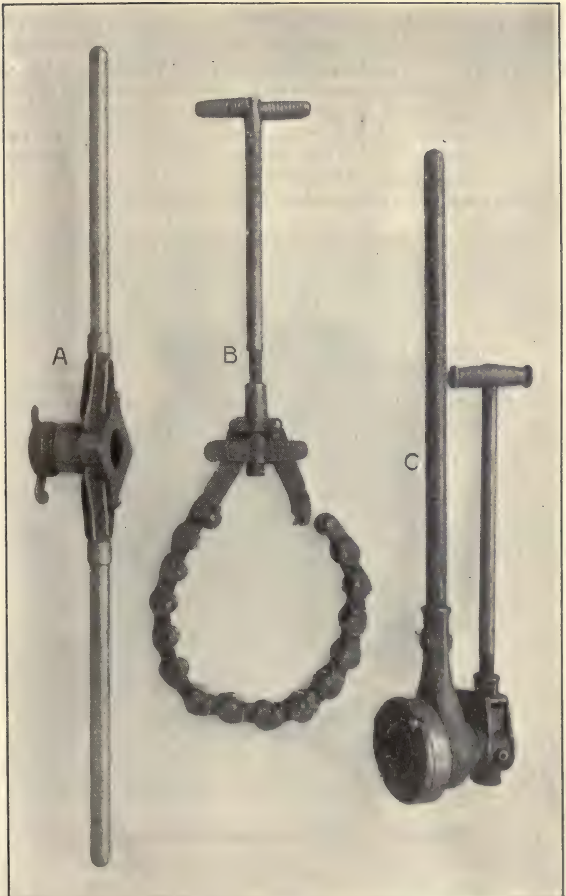


Figure 27.—A, Solid Pipe Stock, page 138. B, Large Pipe Cutter, page 138. C, Climax Ratchet, page 140.

Adjustable

There are a number of good adjustable stocks on the market and which give very satisfactory results. They should be made of high grade malleable iron, thus allowing them to be both light and strong. The dies should be of the best special tool steel, and quick opening, being instantly released from the work without running back over the finished threads. The stocks are made in various sizes, but the size which threads pipe from 1-to 2-inch inclusive, will answer most requirements.

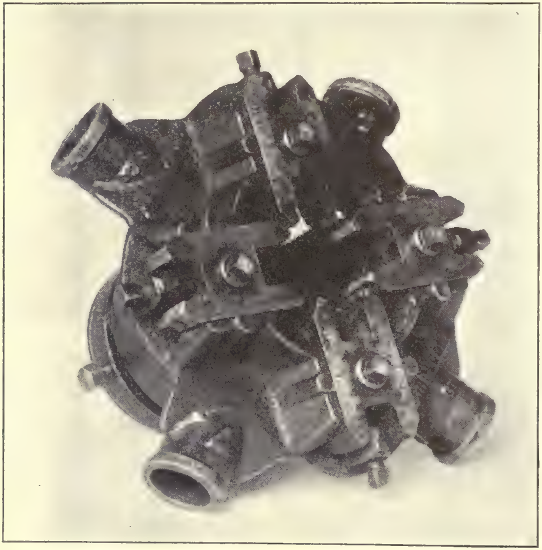


Figure 28. — Four-arm Spider, page 141.

Climax Ratchet

This stock, C, Figure 27, combines the properties of pipe vise and pipe stock, and threads can be cut with pipe in any position.

This is useful especially in trench work. The stocks should be made of malleable iron and steel, reasonably light in weight, but built to stand hard usage and rough treatment. They should be of such size as to fit any standard make of solid square dies. The two sizes most useful are one for $\frac{1}{8}$- to 1-inch pipe, and the other for $\frac{3}{4}$- to 2-inch pipe.

Four-Arm Spider

This stock, Figure 28, should be made of malleable iron and steel, and built to stand very hard usage. It is used for cutting threads on pipe from $2\frac{1}{2}$ to 4 inches in size, is not automatic, and has four heavy chasers bolted on one side for cutting the threads. It is very heavy and clumsy, and is suitable only where very few threads are to be cut. For a larger number, a portable hand-power threading machine should be used.

Hand-Power Pipe Machine for Large Pipe

There are a great many hand pipe-machines on the market but very few give entire satisfaction, and before any are purchased, it pays to examine them thoroughly, and, if possible, make a working test. Machines of this type should have adjustable expanding chasers. The die head should be quick opening and closing, and adjustable instantly to all variations. Also, the chaser slots should be so made that they can be cleaned out without taking the die head apart. The machine should be so designed as to enable a man at the crank to do continuous work with ease. There should be double gears, one being a "slip gear," so that when cutting small sizes, or the first easy threads of larger pipe, one gear is disengaged and the machine drives fast; when the work becomes heavy, both gears are engaged and the crank turns easily.

Pipe Dies

It is very important that dies be made of the best materials and workmanship, as an inferior quality will give very short service and bad results. The cutting parts should be sharp, have proper clearance, and be carefully tempered. The question of clearance is important, especially when steel pipe is being used. The Nye die, which omits one-half of the usual cutting edge, has done good work. In this die, considering any vertical row of cutting edges, each alternate thread is omitted, and considering any horizontal row, each alternate cutting edge.

A very good discussion of die design and pipe threading will be found on pages 1082 to 1086 of the 1914 American Gas Institute Proceedings.

Combination Tap and Drill

This tool, C, Figure 29, is used for drilling and tapping holes in gas mains for service connections, bag holes, etc. It drills, reams and taps a hole in one operation. The end of the shank has a square head, and fits the ratchets used with the drilling machines.

Twist Drill and Tap

For drilling and tapping holes in mains when placing hat flanges, etc., commercial twist drills and taps are used.

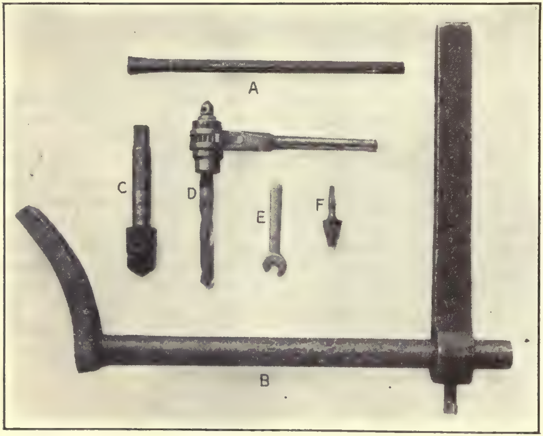


Figure 29.—A, Star Drill, page 142. B, Drilling Post, page 143. C, Combination Tap and Drill, page 142. D, Ratchet Drill, page 143. E, Engineer's Wrench, page 146. F, Pipe Reamer, page 143.

Star Drill

This drill, A, Figure 29, is used in drilling holes through brick, concrete, slate, etc., especially when neat holes are desired. It

is made of good tool steel, and the drill point consists of four cutting edges, which centre at the centre of the drill, and are 90° apart. The cutting edges are drawn out rather blunt, and are tempered hard and tough.

Drills for holes up to 1 inch inclusive are made of octagonal steel from $\frac{3}{8}$- to $\frac{1}{4}$-inch less in diameter than the hole to be drilled, so that the diameter of the drill point will be somewhat larger than the octagonal steel used, and thus prevent the drill from sticking. Drills for holes from $1\frac{1}{4}$ to 2 inches inclusive are made of 1-inch octagonal steel.

Pipe Reamer

Pipe reamers are used to remove the burrs from cut pipe, and are made of fine tool steel. The ordinary commercial burring reamer, F, Figure 29, carefully ground, gives good results.

"Old Man" or Drilling Post

This tool, B, Figure 29, consists of an adjustable swinging arm, fastened to a $1\frac{3}{4}$-inch round wrought-iron post, 20 to 26 inches long, provided with a curved foot, which has a 4-inch slot for the insertion of the bolt used for fastening the foot to the cast-iron main. This swinging arm has a radius of about 18 inches, and its under side is countersunk at regular intervals to receive the pointed head of the boiler ratchet. A set screw rigidly clamps the arm at any position on the post.

Ratchet Drill

These ratchets are used in drilling holes in gas mains when placing hat flanges, and also are used occasionally under various other conditions. They are made of good tool steel, with a ratchet handle and taper hole in socket for the shank of drill.

The pressure is produced by a male feed screw in the centre of a sleeve, which screws into a female thread opening in the body of the ratchet. The sleeve has two small holes, and by the use of a small pin, it can be turned and the pressure regulated as desired. The No. 1 Packer ratchet drill, D, Figure 29, having a handle 12 inches long, gives good results for general use. For very heavy work, a larger size should be used.

Drilling and Tapping Machines

In tapping holes in gas mains, it is very essential that as little gas escapes as possible, mainly to insure the safety of the men

operating the machine. A desirable tapping machine should be of rigid substantial construction, be provided with a positive safety attachment to prevent the escape of gas, easy to handle and manipulate, have few parts, and it should be possible to easily replace or repair the wearing ones. It should be equipped to drill, ream and tap a hole in one operation, and should be operated by a ratchet. As it frequently is necessary to tap large

Figure 30. — Small Tapping Machine, page 146.

holes, it is advisable to have a light machine for tapping holes from $\frac{3}{4}$ to 2 inches in diameter, and a heavy machine for tapping holes over 2 inches in diameter.

Figure 31. — Large Tapping Machine, page 146.

The Mueller combination machine, Figure 30, for drilling and tapping holes from $\frac{3}{4}$ to 2 inches in diameter, is very satisfactory for general service and main work. The Light machine, Figure 31, for drilling and tapping holes over 2 inches in diameter, gives good results.

Rubber Saddle

These saddles, A, Figure 32, are made of fairly tough flexible rubber, and in various sizes and thicknesses to fit the different sized mains and drilling and tapping machines.

Wrenches

Machine Screw

The ordinary commercial machinist's screw wrench, of substantial construction, with a knife-handle, and manufactured in different sizes from 6 to 21 inches over all, will be found satisfactory.

Pipe

A wrench for general pipe work should be drop-forged from steel, and should have as few parts as possible, all of which should be interchangeable. The wrench should not lock upon the pipe, but grip it firmly without lost motion, and should release its hold readily. For general pipe work, wrenches of the Trimo pattern, with steel handle, and manufactured in different sizes up to 48 inches length over all when open, give very good results.

Chain Pipe

This wrench, C, Figure 32, consists of a handle with one or two jaws at one end and a length of chain, and is used in handling large sizes of screw pipe in service and main work. The wrenches are drop-forged from steel, and the length of the chain depends upon the maximum size of pipe the wrench is designed for. They are manufactured in various sizes, and a number of good wrenches are on the market.

Engineer's

This wrench, E, Figure 29, is drop-forged from good steel, with a single head and tapered handle, and the slot is set at an angle of 15°. These wrenches are made to fit any United States Standard nuts.

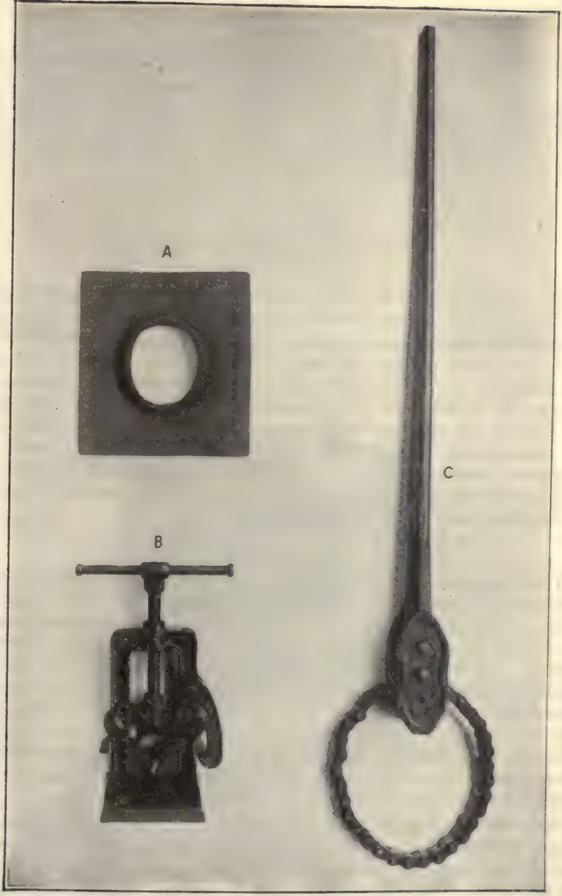


Figure 32.—A, Rubber Saddle, page 146. B, Small Pipe Vise, page 148. C, Chain Pipe Wrench, page 146.

Pipe Vise

Flat drilled base, hinged, malleable pipe vises, with removable jaws and few working and wearing parts, give good results. They are manufactured in various sizes, but for general main and service work, the small vise, B, Figure 32, which takes pipe up to 2 inches in diameter, and the large vise, which takes pipe up to 4 inches diameter, will be found ample.

Lead Joints

Furnaces

Coke

The commercial lead coke furnace, B, Figure 33, made of sheet iron about $\frac{1}{8}$-inch thick, with a rigidly attached frame for supporting the lead pots, a heavy cast iron grate, and supported on legs, or a pair of iron wheels, is satisfactory. These furnaces are made in 18-, 24- and 30-inch sizes, but the 24-inch diameter furnace is best suited for general work. Heavy cast iron pots, A, Figure 33, with wrought iron handles, should be used, and for the 24-inch furnace, the pot should be about 14 inches in diameter and 13 inches deep. Such a pot would be used for pipe 16 inches and larger, and for smaller pipe, a pot 12 inches in diameter and 11 inches in depth.

Gasoline

This furnace, Figure 34, though similar to the ordinary plumber's gasoline coil furnace, is considerably larger and of more substantial construction. The cast iron gasoline tank is 15 inches in diameter and 6 inches deep, and holds about 5 gallons. A heavy wrought iron frame supports the 15-inch diameter cast iron table, on which rest the lead pot and shield. The gasoline tank has a number of lugs, and is bolted rigidly to the wrought iron frame, so that the bottom of the tank is about 6 inches from the ground. The coil is $\frac{1}{4}$-inch pipe, and there are three jets. Heavy cast iron pots, with wrought iron handles, are used with the furnace.

Another type of furnace consists of a carriage mounted on large, flat-tired, iron wheels, and carrying a furnace or kerosene burner equipment, consisting of fuel tank, air tank, pump, and gauge. The specially adapted burner is said to consume fuel at a rate which would bring the cost per pound of lead melted considerably under the cost obtained by the use of coke.

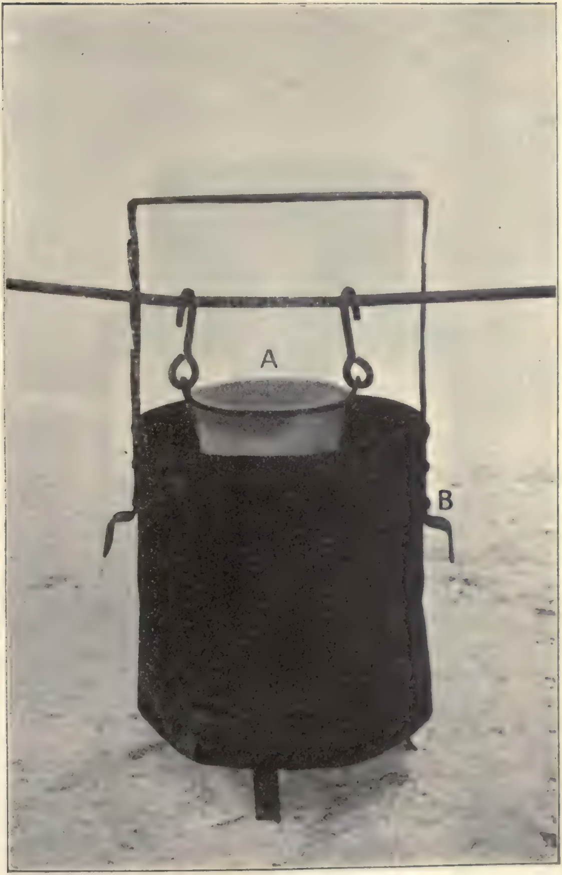


Figure 33. —A, Lead Pot, page 148. B, Coke Furnace, page 148.

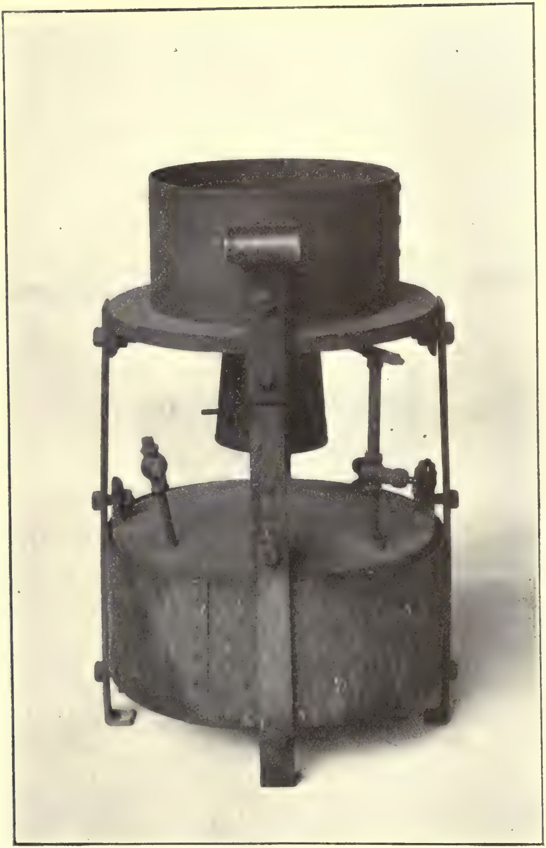


Figure 34. — Gasoline Furnace, page 148.

The portable feature is of advantage, but the apparatus requires considerable care while in transportation, and, in general, is more liable to damage than is the coke type.

Gas

Furnaces similar to the coke furnace, and equipped with a gas burner, are on the market. Although efficient, portability is completely sacrificed, and it is thought that this type is of little advantage.

Lead Strainer

This tool, F, Figure 35, consists of a perforated, saucer-shaped scoop, to which is rivetted a handle 3 feet long, made of $\frac{1}{2}$-inch iron. The end of the handle has a handhold, and the tool is used for removing foreign matter from the surface of the molten lead.

Pouring Ladle

These ladles, A, Figure 35, are used in dipping lead out of the pot and pouring it in the joint. They are made of cast iron, with wrought iron or seamless steel handles, and have lips to aid in pouring the metal. Dimensions are as follows:

Size of Pipe	Diameter of Ladle	Length of Handle
4 to 12″	8″	2′ 9″
16 to 20″	9″	3′ 0″
24 to 30″	10″	3′ 4″

Pouring Pot

Especially for large main work, cast iron or pressed steel pots, C, Figure 35, with handles, lips, and a lug with a small hole, which fits the pot hook, are used. Their dimensions are as follows:

Size of Pipe	Diameter of Pot	Depth of Pot	Thickness of Cast Iron
6″	$5\frac{1}{2}$″	$3\frac{1}{2}$″	$\frac{1}{4}$″
8″	6 ″	4 ″	$\frac{1}{4}$″
12″	7 ″	4 ″	$\frac{1}{4}$″
16 and 20″	8 ″	$6\frac{1}{2}$″	$\frac{3}{8}$″
24 and 30″	9 ″	$8\frac{1}{2}$″	$\frac{3}{8}$″

Pouring Pot Hooks

There are three forms of these hooks. The first, D, Figure 35, is made of $\frac{3}{8}$- or $\frac{1}{2}$-inch round iron, about 6 inches long, with a

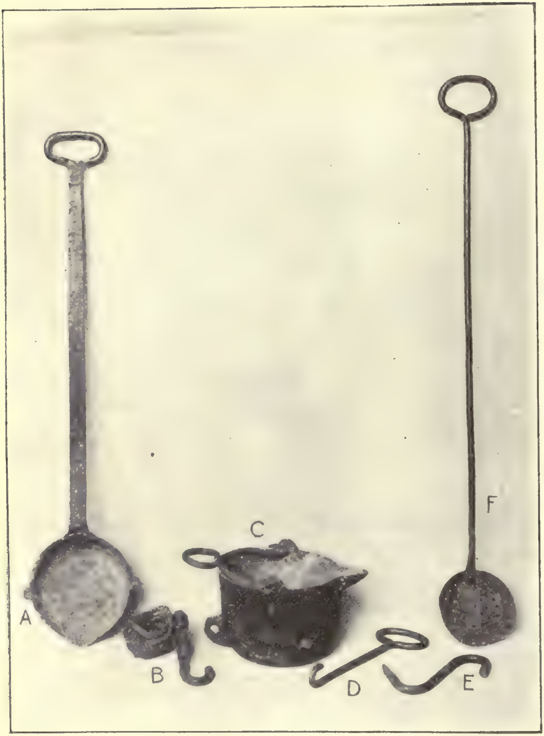


Figure 35. — A, Pouring Ladle, page 151. B, Pouring Pot Hook, page 153. C, Pouring Pot, page 151. D, Pouring Pot Hook, page 151. E, Pouring Pot Hook, page 153. F, Lead Strainer, page 151.

rather sharp pointed crook at one end, and a handhold at the other. The second, B, Figure 35, has at the upper end an eye for attaching rope, and is used for large pouring pots or in deep trenches. The third, E, Figure 35, is the one used to dump the pouring pot.

Figure 36.—A, Pouring Band, page 154. B, Trowel, page 155. C, Caulking Hammer, page 154. D, Gloves, page 157. E, Bellows, page 157.

Pouring Band

A band, A, Figure 36, is made of alternate strips of heavy canvas and thin rubber, cemented and rivetted together, and backed by a thin flexible iron strap, which, with the canvas, prevents the band from stretching. It is provided with a thumb draw-screw to hold it in position on the pipe. The following are the dimensions of the various bands for the different sizes of pipe:

Size of Pipe	Length of Band	Cross Section of Band	
		Width	Depth
4″	1′ 4″	$\frac{7}{8}$″	1 ″
6″	1′ 9″	$\frac{7}{8}$″	1 ″
8″	2′ 4″	$\frac{7}{8}$″	$1\frac{1}{8}$″
10″	2′ 9″	1 ″	$1\frac{1}{8}$″
12″	3′ 4″	1 ″	$1\frac{1}{8}$″
16″	4′ 5″	1 ″	$1\frac{1}{8}$″
20″	5′ 6″	$1\frac{1}{4}$″	$1\frac{1}{8}$″
24″	6′ 8″	$1\frac{3}{4}$″	$1\frac{1}{2}$″
30″	8′ 2″	$1\frac{3}{4}$″	$1\frac{1}{2}$″

Yarning and Caulking Tools

Figure 37 gives details of a yarning iron and a set of caulking tools for general lead work. These caulking tools vary in thickness by one-eighth of an inch. This is the usual variation, although a difference between each tool of but one-sixteenth of an inch would tend to produce better lead compression. Yarning irons one-eighth of an inch thick sometimes are necessary for work on small joints, caused by the irregular casting of specials.

The caulking tools are made of $\frac{7}{8}$-inch, and the yarning iron of 1-inch octagonal tool steel. The heads are dressed carefully, and the points are tempered medium hard.

Caulking Hammer

This tool, C, Figure 36, is hand-forged from tool steel, weighs 3 pounds, and has a substantial hickory handle about 10 inches long. It is used for both lead and cement joints.

Cement Joints

Sieve

A, Figure 38, shows a commercial sieve, 18 inches in diameter and 24 meshes to the inch. It serves to remove hard particles and foreign matter from the cement used in joint making.

Trowel

The bricklayer's trowel, B, Figure 36, with an 8-inch blade of good steel, is used in mixing cement, removing dirt from bottoms of mains, etc.

Hoe

A hoe, C, Figure 38, with an 8-inch blade and a 4-foot handle, will be found very useful when mixing cement in large quantities.

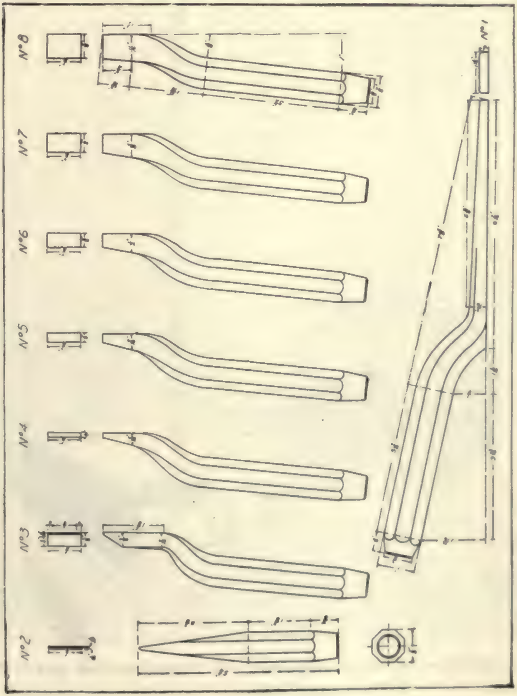


Figure 37.—Lead Yarning and Caulking Tools, page 154.

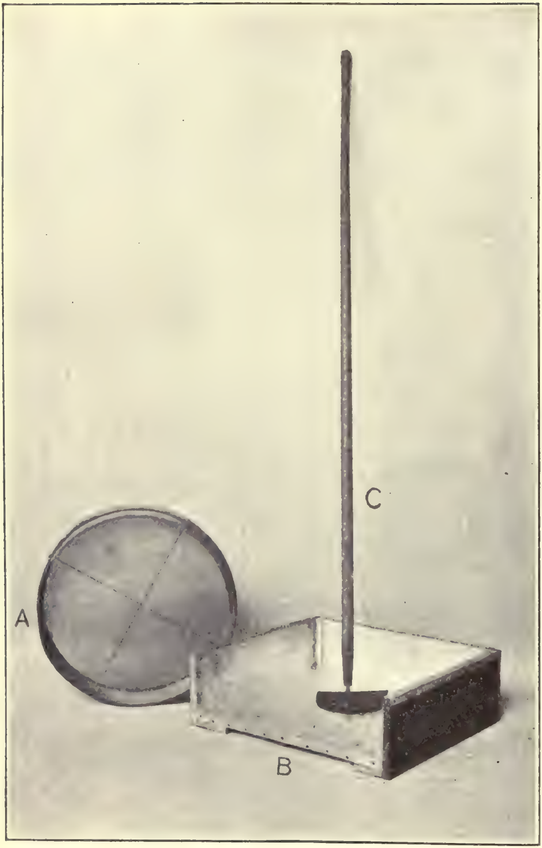


Figure 38. — A, Sieve, page 154. B, Mixing Board, page 157.
C, Hoe, page 155.

Mixing Boards

Mixing boards, B, Figure 38, are made in two sizes, 27 by 35 inches, and 24 by 24 inches. One kind is made of $\frac{3}{4}$-inch rough lumber, having a 6-inch raised edge on three sides, and lined with No. 18 gauge galvanized sheet iron. For another type, heavy galvanized iron is used, with no wood backing.

Bellows

A 12-inch moulder's bellows, E, Figure 36, with a steel spout, will be found very useful to remove the loose pieces of yarn and dirt from the jointing space.

Rubber Gloves and Mitts

Rubber gloves or mitts, D, Figure 36, are used in filling and stuffing pipe joints with cement, and are made of rubber lined with canvas, to prevent irritation of the skin.

Pusher

A pusher, or stuffing tool, Figure 39, used to push the cement into large joints, is made of flat iron $1\frac{3}{4}$ inches wide, $\frac{1}{4}$-inch thick, and 14 inches long. To one end is rivetted a $\frac{3}{8}$-inch steel pipe handle.

Yarning and Caulking Tools

Figure 39 gives details of a set of yarning irons and caulking tools for caulking or driving large cement joints. A caulking tool, slightly curved to approximately conform to the curvature of the pipe, and about $1\frac{1}{4}$ inches wide and $\frac{3}{8}$-inch thick, is very satisfactory for general cement joint work. For large joint work, it is advisable to have all caulking tools quite heavy, and for the heaviest work, $1\frac{1}{4}$-inch octagonal tool steel should be used. The heads are dressed carefully, and the points are tempered medium hard.

Lead Wool Joints

Yarning and Caulking Tools

Hand

Figure 40 gives details of a set of caulking tools for general lead wool work. These tools are made of 1-inch octagonal tool steel, and are similar to the caulking tools used on poured lead joints, with the exception that the caulking toe is made longer, and it is advisable to have the thickness of the end of the toe just about equal the thickness of the lead wool joint to be caulked.

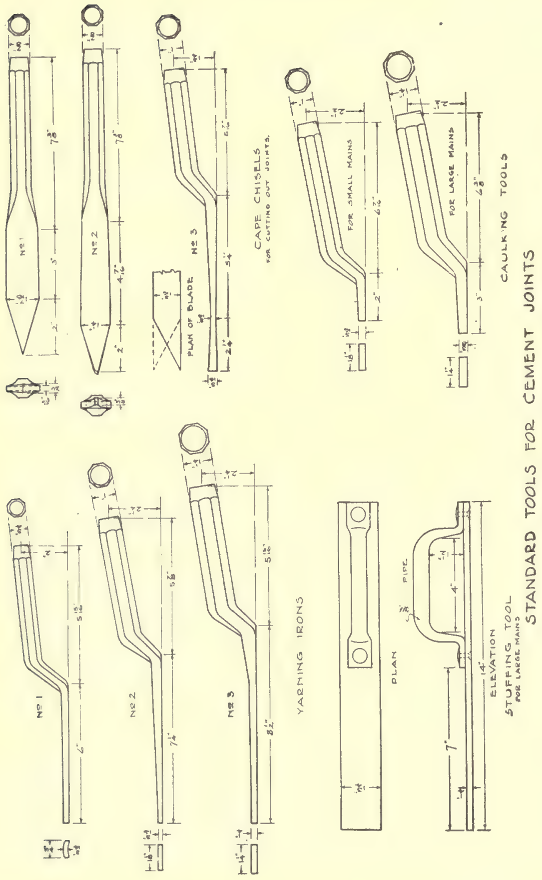
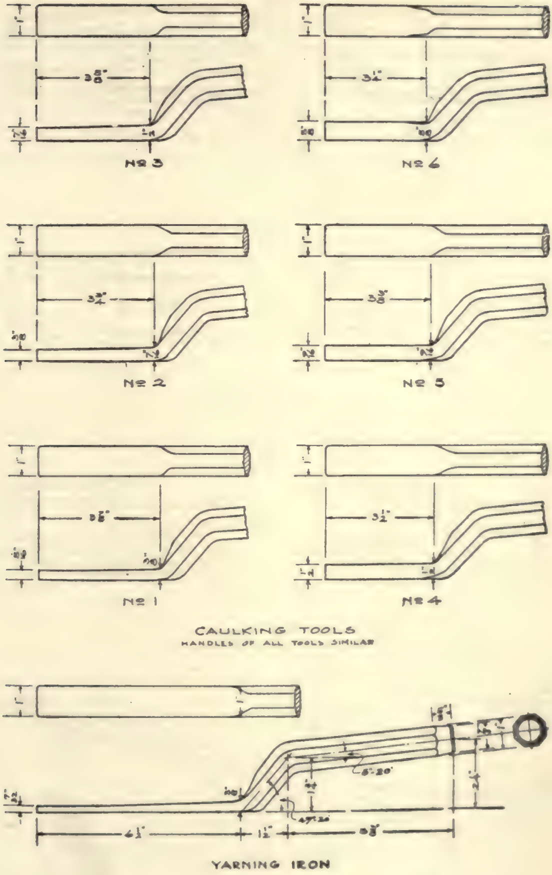
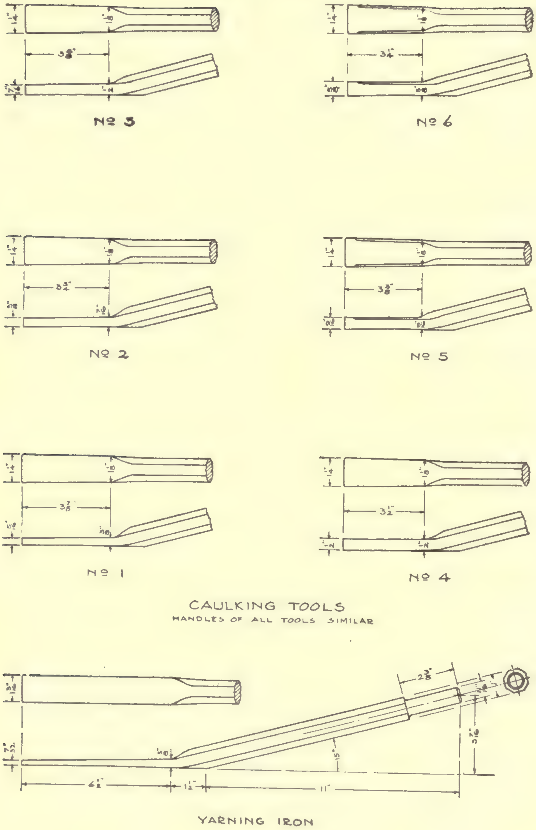


Figure 39. —Cement Yarning and Caulking Tools, page 157.



HAND LEAD WOOL CAULKING TOOLS

Figure 40, page 157.



POWER LEAD WOOL CAULKING TOOLS
Figure 41, page 161.

Pneumatic

These tools, Figure 41, for the various yarning and caulking work, are made similar to those for hand work, with the exception that the shank is made slightly longer, and the end of the shank is machined off so as to fit the pneumatic hammer used. Care should be exercised in making, and the tempering should be carefully done, or there will be a great deal of breakage in use.

CHAPTER XVIII

MAINTENANCE EQUIPMENT

Drip Work

Drip Wagon

Horse

A drip wagon is needed to convey the condensation pumped out of the street drips to the settling tanks at the works or holder stations. Figure 42 shows a type of horse-drawn wagon, consisting of a heavy wrought iron cylindrical tank of 200 gallons capacity, mounted on a wagon body, with a small measuring tank above the main tank, so that the condensation taken from each drip can be measured accurately. The outlet from the tank is 2 inches, to provide for rather quick emptying and also to render unlikely any stoppage, although under proper conditions of manufacture, the condensation should consist solely of water and light oils. There is a covered seat to protect the driver from the weather, and provision is made for necessary tools. The drip pump is shown fastened to the wagon with a fixed wrought iron discharge pipe emptying into the measuring tank. This enables one man to look after all drip work where the condensation is not very great. There undoubtedly is more trouble experienced in keeping the pump in good order than is the case where the pump is not attached to the wagon but screwed on to the drip standpipe. In that case, however, all the condensation has to be lifted in buckets to the top of the measuring tank, greatly increasing the labor.

The proper size for the drip wagon will depend largely upon local conditions. Wherever the absolute amount of condensation is small, a one-horse wagon is advisable, and under ordinary conditions, this would mean a tank of 250 to 300 gallons capacity, depending upon the character of paving, grades encountered and quality of stock. Where the company is large, with big leading mains from which a great amount of condensation is taken,

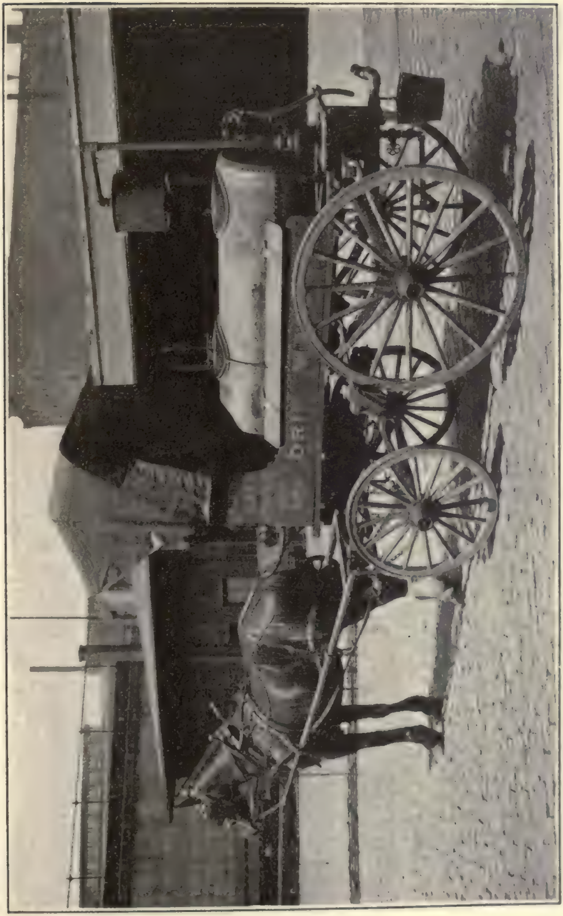


Figure 42. — Horse Drip Wagon, page 162.

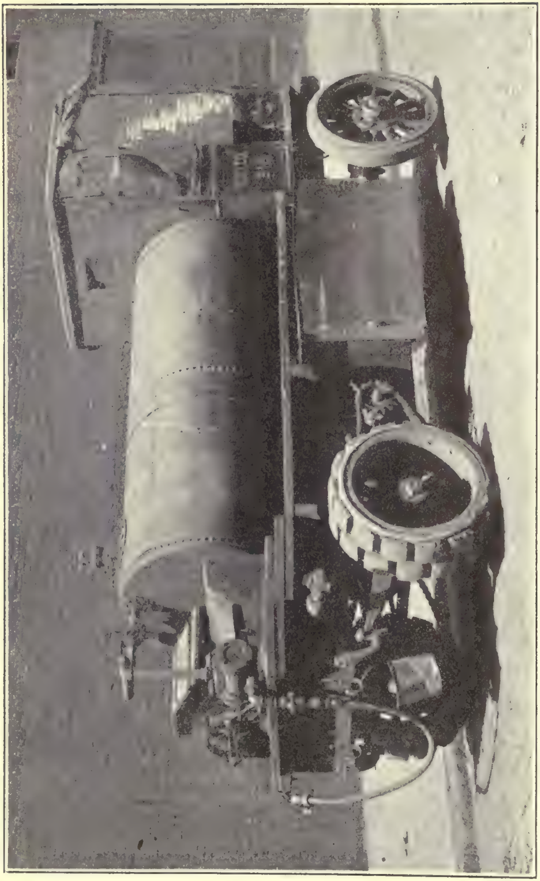


Figure 43. Electric Drip Wagon, page 165.

especially in winter, a two-horse wagon with a tank capacity of 400 to 700 gallons is advisable. Usually there will be need in such a company for more than one wagon for at least part of the year, and there will be a chance for good judgment in planning the work for the two types.

Motor

With the increasing reliability of motor vehicles comes a wider field for the motor drip wagon. In 1912, a trial was made in Philadelphia of a tank mounted on a 4000-pound electric chassis. This resulted in the purchase of a 7000-pound chassis and 600-gallon tank, which began work August 5, 1912, and has been in continual operation since then. The electric wagon was chosen because the garage most conveniently located for the drip work contained solely electric wagons, and also because it was believed that a storage battery would prove more dependable than a gasoline motor. After three years, it is certain that an electric drip wagon always may be depended on for service day in and day out, but there are mileage limitations to the battery which sometimes prove annoying. For this reason, and because of the improvements in gasoline trucks, Philadelphia, needing a second motor wagon, purchased a five-ton gasoline chassis surmounted by a 1300-gallon tank.

Figure 43 is a rear view of the electric wagon. The first pump used was a rotary, but experience showed that a direct-acting pump stood the wear better, so a double-acting force pump, shown in the illustration, was purchased and connected to the motor with a jack. When this pump wears out it will be replaced with a double-acting piston pump, geared directly to the motor, and thus requiring less space for the layout.

This wagon pumps over 600,000 gallons of condensation each year, with an average of over 100 gallons per stop, at a cost, including interest and depreciation, of six-tenths of a cent per gallon.

Drip Pump

A drip pump, G, Figure 44, is used to draw condensation from drips and to clear services. A brass pump, with 12-inch stroke and a cylinder of 2¼ inches diameter, and with the suction fitted for ¾-inch steel pipe, is best suited for general work.

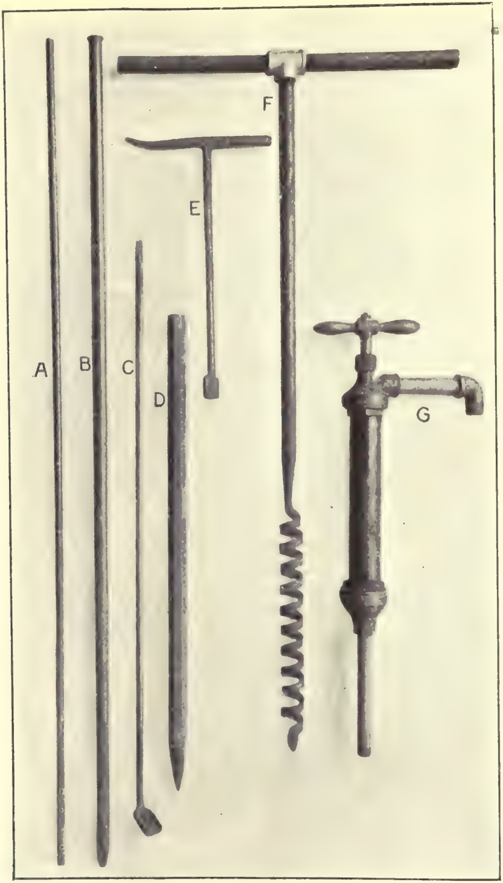


Figure 44.—A, Smelling Pipe, page 167. B, Searching Bar, page 167. C, Spoon Bar, page 169. D, Leak Bar, page 167. E, Drip Key, page 167. F, Leak Drill, page 167. G, Drip Pump, page, 165.

Drip Key

This key E, Figure 44, is used in removing the plugs from the top of drip rods. It is 20 inches over all. The stem and 12-inch cross arm are made of $\frac{5}{8}$-inch round iron, and the hole in the end is made to fit the head of the plug at the top of the drip rod.

Leak Work

Bars

Leak

This bar, D, Figure 44, is used to make openings through asphalt paving, concrete paving foundations, and hard or frozen earth near the surface, so that the street leak drill and searching bar can be driven and drawn more easily. It is made of $1\frac{3}{8}$-inch octagonal steel, 2 feet $8\frac{1}{2}$ inches long, and has a carefully dressed head and point. The point is tempered so as to be hard and tough.

Searching

A searching bar, B, Figure 44, is used in barring for leaks over mains and services, and is made of $1\frac{1}{8}$-inch round steel, with a rather blunt point, similar to that of the ordinary street bar. It generally is made 5 feet long, but where mains are deep, or it is advisable to drive the bar at an angle so as to reach the bottom of large mains, a longer bar must be used.

Smelling Pipe

A smelling pipe, A, Figure 44, is used to facilitate the escape of gas from bar holes to some distance above the surface of the ground, so that slight leaks can be detected more easily. It is made of $\frac{3}{8}$-inch steel pipe, 5 feet 6 inches long, open at both ends, and has a number of $\frac{1}{4}$-inch drilled holes near one end.

Leak Drill

This tool, F, Figure 44, is used in drilling holes through the earth over mains and services when searching for leaks. It consists of a piece of half-round steel, $\frac{3}{4}$-inch diameter, made with the flat side out, into a twist drill 18 inches long, and 2 inches in diameter, and welded to a stem of 1-inch steel pipe, the over-all length being 4 feet 6 inches. A 1-inch tee is screwed to the end of the 1-inch pipe, and two pieces of 1-inch steel pipe, each 13 inches long, are screwed into the tee, forming levers or handles. Another type of handle is made by removing the pipe handles and slipping a searching bar through the tee.

The drill was designed in order to avoid, as far as possible, the use of the leak bar, substituting drilling for driving, and in this way rendering more unlikely the piercing of any tile-covered conduit. It has been found that the drill cannot be made to enter through hard frost, but, except under such conditions, its use is advocated wherever there are congested underground conditions, and the danger of driving the ordinary leak bar through other structures cannot be ignored.

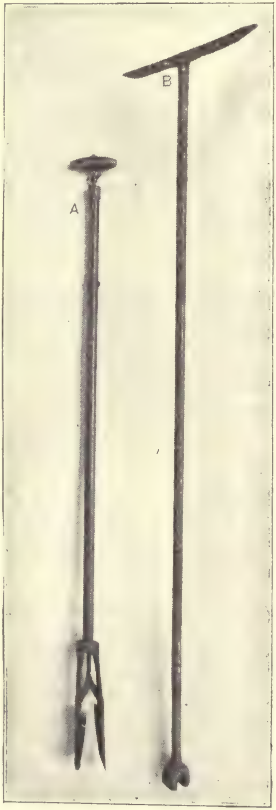


Figure 45. — A, Stop Box Cleaner, page 168. B, Stop Cock Key, page 168.

Stop Box Work

Stop Box Cleaner

This cleaner, A, Figure 45, consists of a 3-foot length of ½-inch steel pipe, through which passes a ¼-inch rod. At the bottom of the ½-inch pipe are attached two pieces of curved steel with a sharp nose, similar to a shovel point. The ¼-inch rod is attached to the steel "wings" in such a way that by pushing down the rod, the "wings" are forced apart, a spring at the top of the rod always tending to hold the "wings" together. A wooden handle is provided at the top end of the rod. The over-all length of the cleaner is about 4 feet.

Stop Cock Key

The illustration, B, Figure 45, shows the key re-

cently adopted by the Philadelphia Gas Works. It is 4 feet 6 inches over all, with stem and handle of $\frac{3}{4}$-inch round iron. The latter has one chisel end to cut the dirt above and around the stop-box cover, which is then lifted by inserting in the centre hole, the blunt end of the handle. The socket shown will fit stop cocks $\frac{3}{4}$ to 2 inches inclusive. Another key, with a larger socket, must be used for the service valves. In order to do away with this need for two keys, an experiment is being tried with a socket provided with a slotted bushing, of such dimensions that with the bushing in place, the key fits stop cocks $\frac{3}{4}$ to $1\frac{3}{4}$ inches inclusive, and with the bushing removed, 2-inch stop cocks and the rectangular heads of all sizes of service valves.

Spoon Bar

This bar, C, Figure 44, is used in cleaning out stop boxes, and is made of $\frac{3}{4}$-inch round steel, 4 feet 10 inches long, with a $\frac{3}{4}$-inch chisel point at one end, and a 2 by $1\frac{1}{2}$-inch rectangular scoop, with the two sides raised about half an inch, at the other end.

Gauges

Syphon Gauge

Syphon gauges, A, Figure 46, with glass U tubes, graduated wooden scales, and provided with couplings and standard pipe thread connections, are frequently useful, and can be obtained easily in any size.

Recording Gauge

Recording gauges are used for the continuous recording of pressures or temperatures through certain periods, and generally consist of a clock mechanism, which revolves a chart supported by a stationary dial and upon which is traced a line by a pen point. The pen point is at the end of an arm attached to a sensitive mechanism, upon which the changes in pressure or temperature act, and this causes a movement of the arm and pen point. The pen points are removable, and can be replaced readily by new ones whenever they become blunt or worn by continuous service.

The Bristol Recording Gauge, B, Figure 46, manufactured in various forms, gives good results. The illustration shows a gauge as mounted in a wooden box, for temporary use on the street or in consumers' houses. In order that these gauges

should be maintained in proper working condition, a periodical inspection is advisable, at least once a year, and preferably before trunk main pressures are taken in the fall.

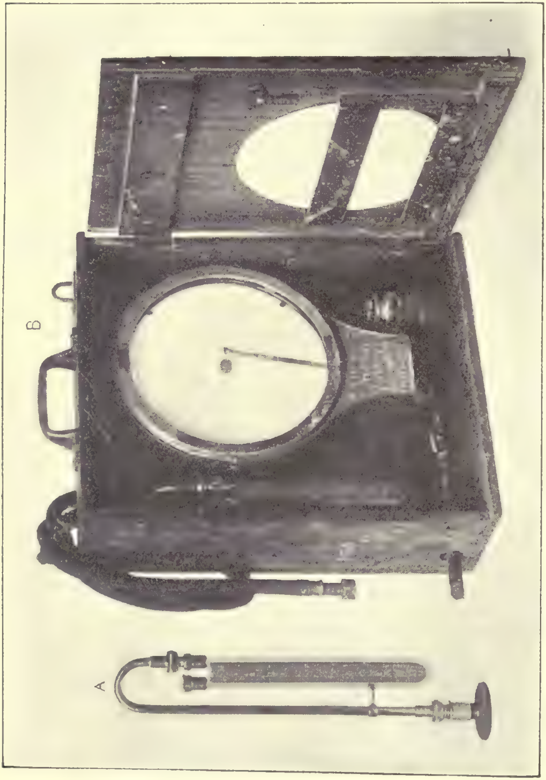


Figure 46.—A, Syphon Gauge, page 169. B, Recording Gauge, page 169.

Figure 47.—Street Lamp Cleaning Ladder, page 172

In making the inspection, the gauge boxes are first examined for condition of box, ink receptacle, chart rack, glass in front of recording gauge, etc. If any of the equipment is missing, a memorandum of it is made on a sheet of paper and placed in the gauge for the use of the man in making repairs. Every gauge is then tested separately by being connected with a convenient gas outlet. Care should be taken to see that the rubber tubing connections at the gauge and at the outlet are perfectly tight, in order to be sure that any drop in pressure is not due to leaks outside of the gauge box. The water gauge is filled with water, and the cock on both the water gauge and the recording gauge is shut off, and the tubing connection made to the gas outlet. The cock on the water gauge is opened, and then closed after the water has risen to a point indicating the pressure. If the water column shows no decided drop for five seconds, the water gauge and connections may be considered tight. In the same way the gas pressure is admitted to, and then shut off from, the

recording gauge through the cock on the supply line. If the stylus arm remains stationary at the pressure indicated when the cock was open, or does not move back except very slowly after a lapse of from 10 to 15 seconds, the diaphragm and the piping beyond the cock on the recording apparatus may be considered as tight. The only test remaining to be made is that portion of the pipe between the two cocks and the outlet from which the gas is being taken. This test is made practically the same way as the other test, except that both the recording gauge cock and the water gauge cock are left open after the gas has been admitted and the cock at the outlet is closed. After the gas is shut off, the pressure should remain stationary for a period of 10 to 15 seconds and not show any decided drop in that time. Ordinarily, all that is required if there is any leakage, is to have the cock re-ground, and any leaking fittings or nipples properly re-leaded. Whatever work of this kind is necessary should be written on a memorandum sheet and placed in the gauge box for the use of the man who will make the repair.

Any adjustment of the stylus arm is effected through its hinged joint. If through improper handling, the pen has been bent out of position, it should be restored to the proper angle of 90° with the plane of the chart.

When a gauge is sent out, it should be packed so that the diaphragm and stylus arm will remain stationary during shipment. This is done by a pair of small clips fastened to the body of the gauge case, and, by means of set screws, lowered into position to hold the diaphragm firm. When the gauge is put into use and the clips again raised, they must be screwed tight to prevent their dropping upon the diaphragm and interfering with its action.

Street Lamp Cleaning Ladder

These ladders, Figure 47, are made of good lumber, and are 9 feet long, 12½ inches wide at the bottom and 9½ inches at the top, with hickory rungs 1 foot apart. The side pieces are of 2 by 1-inch straight-grain spruce. Wrought iron spikes are placed at the bottom of the ladder, and at the top, wrought iron hooks, which fit the iron ladder bar on the lamp post.

CHAPTER XIX

MISCELLANEOUS EQUIPMENT

Tool Wagon

Where a company has occasion to lay long stretches of large mains, involving many workmen, and, therefore, much equip-

Figure 48. — Tool Wagon, page 174.

ment, the ordinary tool box may be too small, and a tool wagon Figure 48, preferable. Its general dimensions are 10 feet long, 4 feet wide, height to eaves, 4 feet, and to ridge pole, 5 feet. It is provided on the outside with side and bottom tool boxes and a lantern rack. The interior has a tool rack, yarn closet, cement bins, a folding and a stationary shelf.

Tool Boxes

The ordinary tool box, Figure 49, is about 6 feet long, 3 feet 6 inches deep, and 3 feet 4 inches wide. If properly handled, it will

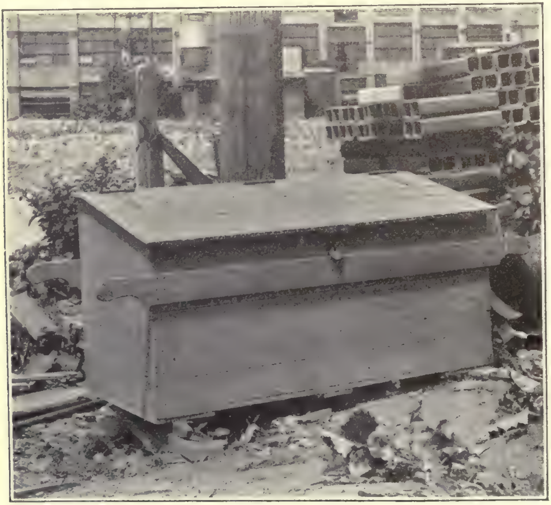


Figure 49. — Tool Box, page 174.

last a long time. It should never be shifted along the work, except when practically empty. If at each end two of the side planks are extended about 3 feet, the box may be easily handled.

Where there is frequent shifting to do, as is the case with a small gang doing many isolated jobs of main work, a tool box,

Figure 50, mounted on wheels, has been used with great satisfaction. The boxes are made of 1-inch oak, mounted on substantial wheels of 26-inch radius, with a 2-inch square steel axle, so bent that the bottom of the box is about 15 inches from the ground. The two supporting beams for the box, which are attached rigidly to the axle, are made of 3 by 3-inch oak. At the front of the cart, there is an extension with a cross piece, used when moving the box. Wrought iron braces and straps are used generously to make the box strong and rigid. The lid is provided with heavy hinges.

Figure 50. — Tool Box on Wheels, page 175.

Service Carts

Wooden

One cart consists of a box 6 feet long, 2 feet 5 inches wide, and 1 foot 3 inches deep, made of 1-inch oak, and mounted on two substantial wheels of 26-inch radius, with a 2-inch square steel axle. In the front part of the box are arranged racks and bins for dies, taps and small tools, while large tools, such as picks, shovels, bars, etc., are placed in the rear part. The lid has heavy hinges. The two main supporting shafts, which are attached rigidly to the axle, are made of 3 by $2\frac{1}{2}$-inch oak. At one end of the box there is an extension with a cross piece, used in moving the cart, and at the other end there is a heavy piece of

oak 4 feet 2 inches by 9 inches by 3 inches, to which is attached a vise which will take pipe up to 2 inches diameter. Between the wheels and the sides of the box, a space 6 inches wide is left. A box 2 feet 6 inches by 1 foot 3 inches by 1 foot 3 inches is placed in under the rear part of the cart, for the storage of oil, tar, etc. Oak braces and wrought iron straps and braces are generously used in the construction of the cart.

Figure 51. — Small Wooden Service Cart, page 176.

Another cart, Figure 51, often of more general use than the one just described, is similar to it, with the exception that the box is smaller, being 5 feet 6 inches long, 1 foot 10 inches wide and 1 foot deep, and the box for the storage of oil is 2 feet by 1 foot 3 inches by 1 foot 3 inches. The main supporting beams are 3 by 2 inches, and the axle is $1\frac{1}{2}$-inch square steel. Its weight is 650 pounds.

Steel

Philadelphia now has many steel service carts, and in future will make all replacements in steel, thus obtaining increased strength, lower maintenance costs, and lighter weight, the latter being 425 pounds. The cart, Figure 52, consists of a box 5 feet $10\frac{1}{2}$ inches long, 2 feet wide, and 1 foot $5\frac{1}{2}$ inches deep, made of $\frac{1}{8}$ by 1-inch angle iron, the frame being covered with No. 18 gauge sheet iron. The body is mounted on two substantial wheels,

3 feet 6 inches in diameter, with steel tires $\frac{3}{8}$ by $1\frac{3}{4}$ inches, and a $1\frac{3}{8}$-inch square steel axle. The arrangement of the racks and bins inside the box is identical with the wooden cart. The two main supporting shafts, which are attached rigidly to the axle and

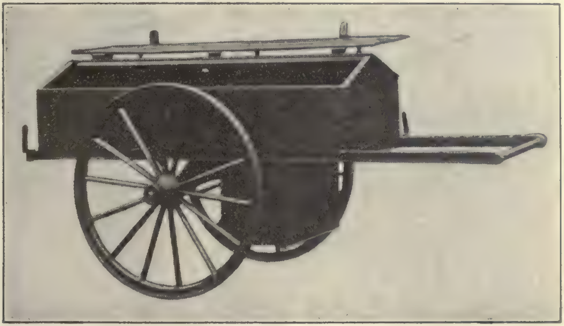


Figure 52. — Steel Service Cart, page 176.

body, are made of 1 by 2-inch channel iron. The bottom of the box is made of galvanized iron, and covered on the inside with maple wood flooring $\frac{1}{4}$-inch thick. The flooring acts as a cushion for the tools, eliminating the noise that otherwise would be caused when the cart was in transit. It also acts as a protection to the bottom of the box. Under the rear part of the cart, a box, made of sheet iron, measuring 1 foot 2 inches by 1 foot 4 inches by 1 foot $10\frac{1}{2}$ inches, is placed for the storage of oil, tar, etc.

For working convenience, and at other times to avoid injury to children, it is important that any rocking of the cart *while at rest* should be impossible. Both of these objects may be attained by fastening to each end of the cart, a rod extending to the ground.

Push Cart

This cart, Figure 53, is used for miscellaneous work, such as stop box work, leak work, and small paving jobs. It is of substantial construction, but not too heavy, with the body supported on springs. Its dimensions are: Length of body at bottom, 30 inches; width, 20 inches; 34-inch wheels.

Figure 53. — Push Cart, page 177.

WHEELBARROWS

Wheelbarrows, Figure 54, for general use, should be made entirely of iron, with wheel guards, and the handles and legs should be braced rigidly. They should be stored out of the weather, and painted whenever they show signs of rusting.

ELECTRIC SAFETY LAMPS

BOX

For night leak work, it is usually necessary to have a fairly strong light of some kind to lower into the ditch. There are a great many electric lamps in the market that answer the purpose. In Philadelphia, several equipments are used satisfactorily. One consists of a box, 9 by 10 by 11 inches, made

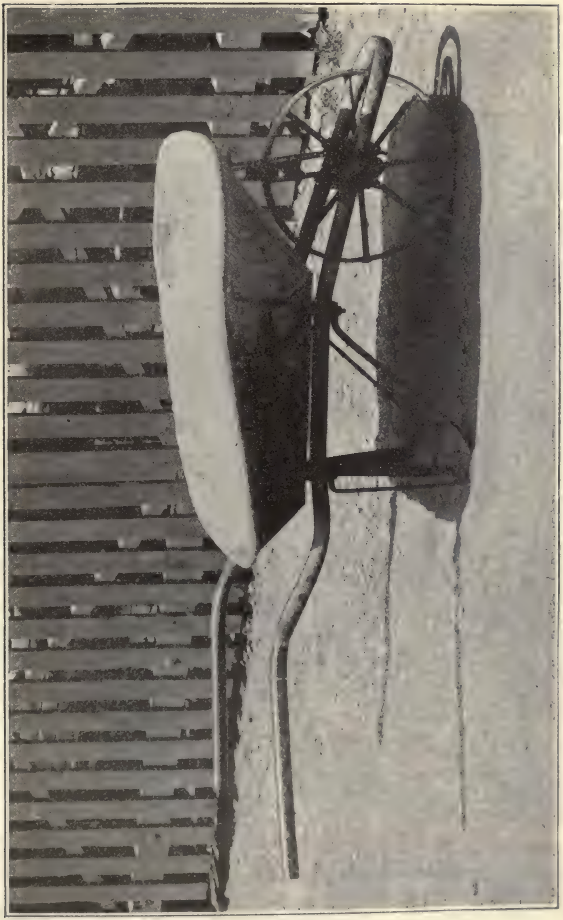


Figure 54. — Wheelbarrow, page 178.

up of six cells with a total of 8 volts and 20 amperes, giving a light of about 6 candlepower. It will be noted that in addition to the light fixed to the box side, there is a light attached to 9 feet of wire. The latter is of great use for out-of-the-way places.

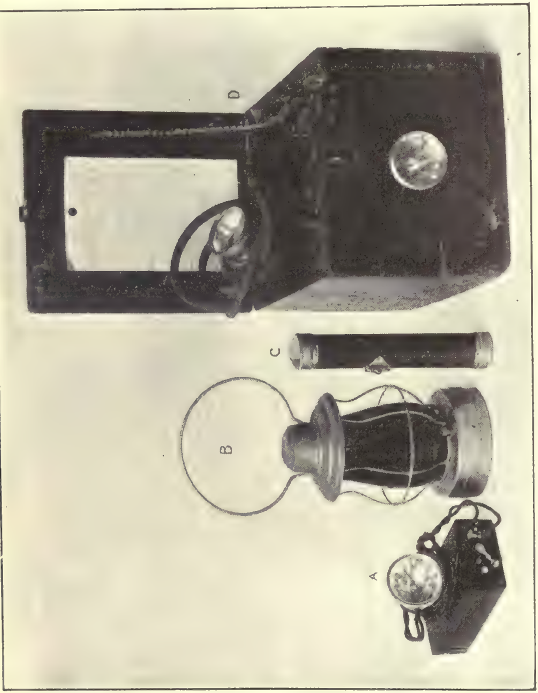


Figure 55. — A, Pocket Lamp, page 182. B, Danger Signal Lamp, page 182. C, Hand Torch, page 182. D, Box Lamp, page 180.

This equipment, D, Figure 55, will last 14 hours of continuous running. In order that these batteries do not fail when needed, a record of the hours of use is kept on the inside of the lid so that the next man using it can tell readily how long it may be expected

to last, or the foreman at inspection can determine when a renewal of cells is necessary.

POCKET

Another very handy equipment, A, Figure 55, is in the form of a dry cell enclosed in a leather box, measuring 1½ by 3½ by

Figure 56.—A, Oxygen Tank, page 182. B, Breathing Bag, page 182. C, Respiration Pipe, page 182. D, Potash Regenerator Cartridge, page 182. E, Nose Clamp, page 182. F, Mouthpiece, page 182. G, Smoke Goggles.

7 inches. Attached to the terminals on the end of the box are long insulated wires leading to the lamp. The lamp itself can be fastened to the clothing or used in the hands. The small size

of the box permits its sliding into the side pockets of a coat very easily. This battery will last for 14 continuous hours, or 28 hours when used intermittingly. The entire equipment can be made for $3.25.

Danger Signal

For use in gaseous atmospheres, where ordinary oil danger signal lamps or any open-flame lamp would be dangerous, an electrically equipped lamp with red globe is used. This lamp, B, Figure 55, can be bought already made up, or the ordinary oil lamp can be converted into electric at small cost. In this case the light socket is soldered to the oil compartment, which is connected to a battery box.

Hand Torch

This torch, C, Figure 55, will slide into the pocket very easily, and is of great assistance in examining dark cellars, manholes, etc., for leaks. It is $8\frac{1}{2}$ inches long and $1\frac{5}{8}$ inches in diameter. The dry battery will last for 10 hours continuous running, or 20 hours of intermittent using.

Respirators

There are many cases where a man is compelled to work in a gaseous atmosphere for some time, both in main and in service work. A respirator, or device that furnishes fresh air to a man so occupied, is illustrated in Figure 56. It consists of an oxygen tank, A; a rubber, cloth-covered breathing bag, B; a respiration pipe, C; a potash regenerator cartridge, D; a nose clamp, E; and a mouthpiece, F. This apparatus rests on the wearer's abdomen and is held tight to the body by a neck strap and belt. After putting it on, the oxygen valve should be opened and the empty bag filled, but not very tight. Then the goggles and nose clamp should be fitted, and the mouthpiece, with holding straps, adjusted. Now the man may work around live gas with impunity, so far as danger from asphyxiation is concerned. He breathes out of and into the breathing bag through the potash, and refills the bag with oxygen when he notices, by feeling, that the supply is becoming low. The cartridges of potash will last for about a half hour, and the oxygen tanks for a couple of hours. A wooden box, shaped like a suit case and containing the extra cartridges, tanks, goggles and so forth, is convenient for storage and for transportation.

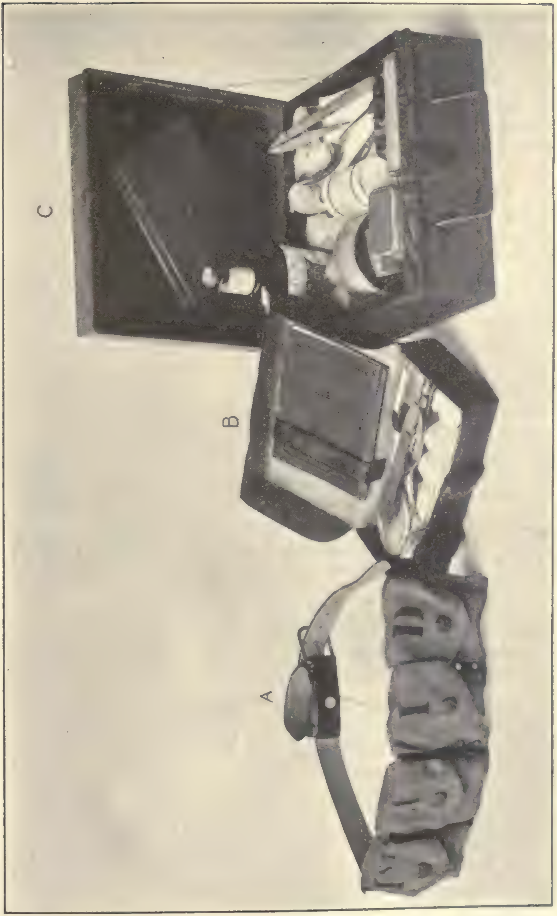


Figure 57. — A, First Aid Belt Kit, page 184. B, First Aid Pocket Kit, page 184. C, First Aid Wagon Kit, page 184.

This apparatus has been used successfully in temporary repairs to broken mains, involving soaping and wrapping against gas pressure, cracks of considerable width. A case in point was a 16-inch main pushed out of line until there was an opening on one side about 6 inches wide. Equipped with the respirator, a workman quickly inserted two stoppers and shut off the gas flow without being in the slightest degree affected.

First Aid Kits

First Aid kits contain supplies to aid persons who are affected or overcome by gas. In Philadelphia, two kinds of kits are in general use, one in the form of a tin box, C, Figure 57, and the other in a leather case, B, Figure 57. The tin box is constructed substantially, measuring $8\frac{1}{2}$ by 9 by 4 inches, with a tight-fitting hinged lid and catch, and wire handle. It is enameled inside and out to prevent rusting. This box is carried on the wagons and carts and, in general, where its contents need protection against severe blows of any nature. The leather case does not contain as many articles as the tin box, due to its size, measuring $8\frac{1}{2}$ by $4\frac{1}{2}$ by $1\frac{3}{4}$ inches. It was made up for the use of complaint men on leak work, etc., and can be carried in a coat pocket. In addition to the two kits above mentioned, a very convenient arrangement has been made in the form of a belt, A, Figure 57, that buckles around a man's waist. It contains pockets in which are carried the various articles needed.

The following shows the contents of the three kinds of kits:

Tin Box

*1 bottle Aromatic Spirits of Ammonia,
2 boxes Vaporole Ammonia Capsules,
1 bottle Phenol Sodique,
*6 bottles Effervescing Sodium Phosphate,
1 roll 2-in. Cotton Bandage,
1 roll 2-in. Gauze Bandage,
1 1-oz. package Absorbent Cotton,
1 roll 1-in. Adhesive Tape,
1 Jaw Block,
1 Folding Tin Cup,
1 pair Tongue Pliers,
1 pair Scissors,
1 Teaspoon,

1 Tourniquet,
2 Towels,
2 Books of Instructions: *First Aid to Persons Overcome by Gas* and *Treatment for Cuts and Abrasions.*

LEATHER CASE

*1 bottle Aromatic Spirits of Ammonia,
2 boxes Vaporole Ammonia Capsules,
*4 bottles Effervescing Sodium Phosphate,
1 Jaw Block,
1 Folding Tin Cup,
1 pair Tongue Pliers,
1 Teaspoon,
1 Book of Instructions: *First Aid to Persons Overcome by Gas.*

LEATHER BELT

*2 4-oz. bottles of Aromatic Spirits of Ammonia,
2 boxes Vaporole Ammonia Capsules,
*3 bottles Effervescing Sodium Phosphate,
1 Jaw Block,
1 pair Tongue Pliers,
1 half-size Teaspoon.

*Only these may be taken internally.

SECTION II

INSIDE WORK

CHAPTER XX

INSTALLATION EQUIPMENT

Meter Work

Meter Setting Gauges

Meter setting gauges are devices used in setting meters, with the idea of straining meters and meter screws as little as possible. They consist of brass screws, similar to the ordinary

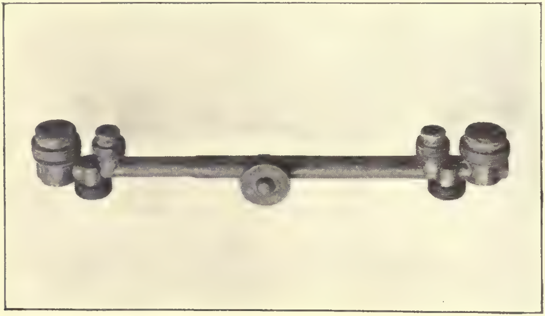


Figure 58. — Meter Setting Gauges, page 188.

meter screws, mounted on seamless steel tubing. One screw is adjustable, and, by means of a set screw, the distance between the screws can be adjusted and the screw held rigidly in the desired

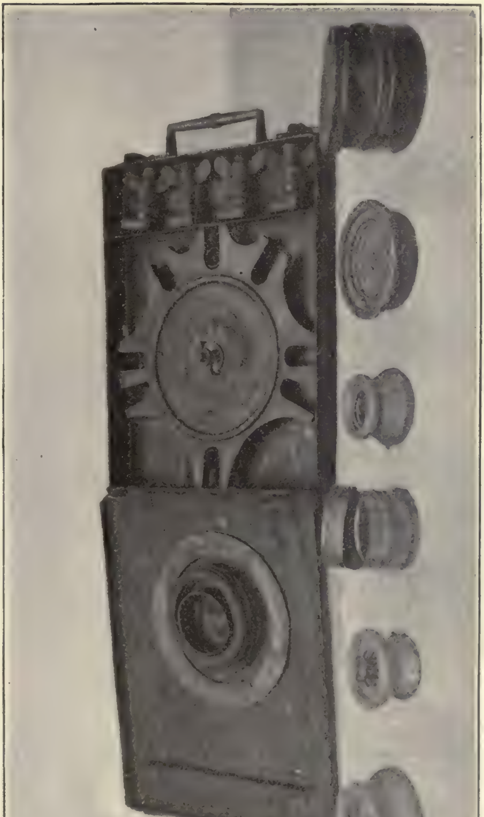


Figure 59. — Meter Test Caps, page 188.

position. The gauges for the 3-, 5- and 10-light, and 150- and 200-light, are combination gauges. Figure 58 shows the former combination. These gauges are useful only with the types of meter connections shown in Figures 132 and 133.

Meter Test Caps

Turn-on

Turn-on test caps, Figure 59, are safety devices used when turning on gas to determine if meters will register at small rates of gas flow. The caps for meters up to 100-light inclusive are made of cast aluminum, and for meters from 150- to 1000-light inclusive, of brass. The different caps have female threads, which fit the different sizes of meter screws, and the large brass cap has, in addition, arms so that it can be bolted to the flange connections of large meters. In the disc of each cap is a hole of proper size to pass 2 cubic feet of gas per hour under 2 inches pressure. The brass cap has an additional hole of 6 cubic feet hourly capacity. Tight-fitting, fabric-covered, rubber washers are used in the joint between the cap and metal screw.

Gradual-Cease-House-Test

In the lower left-hand corner of Figure 59 are shown two test caps used in gradual-cease-house-tests. The smaller is for 5-A, 10-A and 20-light, and the larger for 30- to 100-light meters. In each the projecting cap is bored with a hole of 3 cubic feet hourly capacity. This cap fits over an opening in the disc, large enough to pass 6 cubic feet per hour, so by its removal each test cap may be used to test the meter at this rate of flow. For meters 150-light and larger, the brass turn-on test cap is used.

Appliance Work

Stove Fitter's Kit

This kit, Figure 60, is used by men who connect gas appliances, and consists of a case made of No. 24 galvanized iron, elliptical in shape, 18 inches long, major diameter 8 inches long, and minor diameter 4 inches long. It has a hinged lid, which can be locked, and is provided with a shoulder strap. The case contains the following equipment:

1 Brace, with extension and search bits,
1 Oil Can,
1 Meter Test Cap, 3- to 20-light inclusive,
2 18-inch Cold Chisels,

1 3-inch Floor Chisel,
1 Cutter, for pipe up to 1-inch inclusive,
1 6-inch Screw Driver,
1 12-inch Half-round File,
1 Ball Pein Machinist's Hammer,
1 pair 6-inch Burner Pliers,
1 12-inch Compass Saw,
1 Stock, with dies and guides for pipe up to 1-inch inclusive,
2 14-inch Trimo Wrenches.

Figure 60. — Stove Fitters Kit, page 188.

LARGE APPLIANCE KIT

This kit, Figure 61, consists of a wooden box with hinged lid, and a hasp and keeper for locking. It is made of $\frac{3}{4}$-inch lumber, and the inside dimensions are: Length, 3 feet 6 inches; width, 1 foot; and depth, 10 inches. The standard equipment in this box consists of the following:

1 Meter Test Cap,
1 Cutter, for pipe up to 2-inch inclusive,
1 Socket Stop Key,

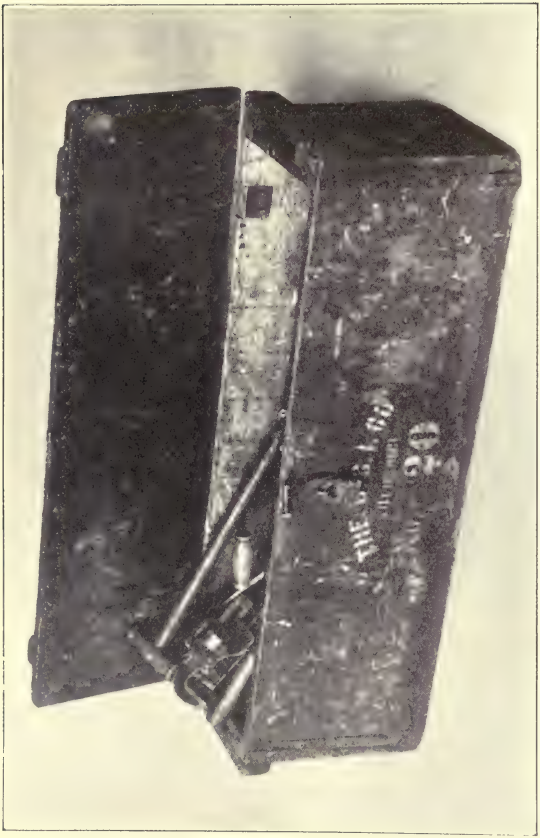


Figure 61. — Large Appliance Kit, page 189.

1 Climax Ratchet Stock, with dies and guides for $1\frac{1}{4}$, $1\frac{1}{2}$ and 2-inch pipe,

2 24-inch Wrenches.

It is used when installing large appliances, and is large enough to hold any additional equipment that may be needed.

Miscellaneous Work

Bits

Expansion

The ordinary type provided with two cutters, and boring holes from $\frac{7}{8}$ to 3 inches, gives very satisfactory results.

Search

These bits are similar to the ordinary bell hanger's bit, and are made of $\frac{1}{4}$-inch steel, 15 inches long.

Braces

The ordinary carpenter's brace of good manufacture, with a reversible ratchet handle, gives good results.

Chisels

Floor

This chisel, A, Figure 62, is used in taking up floor boards, and is made of $\frac{5}{8}$-inch octagonal steel, 15 inches long. One end is drawn out to a sharp cutting edge, 2 inches wide, and the head is dressed carefully.

Wall

This chisel, B, Figure 62, is used in cutting holes through walls, and is made of $\frac{3}{4}$-inch octagonal steel, 18 inches long. One end is drawn out to a fairly sharp chisel point, $\frac{3}{4}$-inch wide, and the head is dressed carefully. The chisel point is tempered to be hard and tough.

Hammer

A ball pein machinist's hammer, weighing about 2 pounds, and having a handle from 9 to 12 inches long, is recommended.

Oilers

Oilers made of No. 20 gauge brass, or cold-rolled steel with tempered steel bottoms and polished, give good results. A size about 3 inches in diameter, holding one-third of a pint, and having spouts 4 inches long, is best suited for general work.

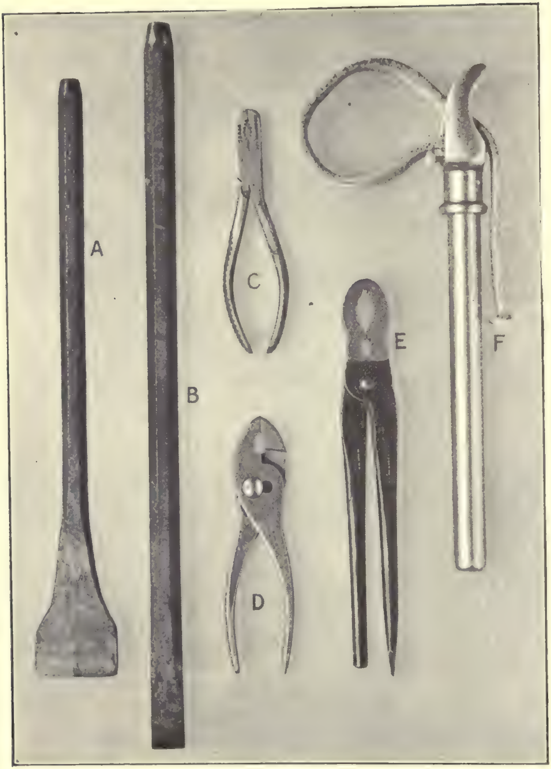


Figure 62.—A, Floor Chisel, page 191. B, Wall Chisel, page 191. C, Burner Pliers, page 193. D, Combination Pliers, page 194. E, Gas Pliers, page 194. F, Strap Wrench, page 194.

Pliers

Burner

These pliers, C, Figure 62, should be drop-forged steel, pol-

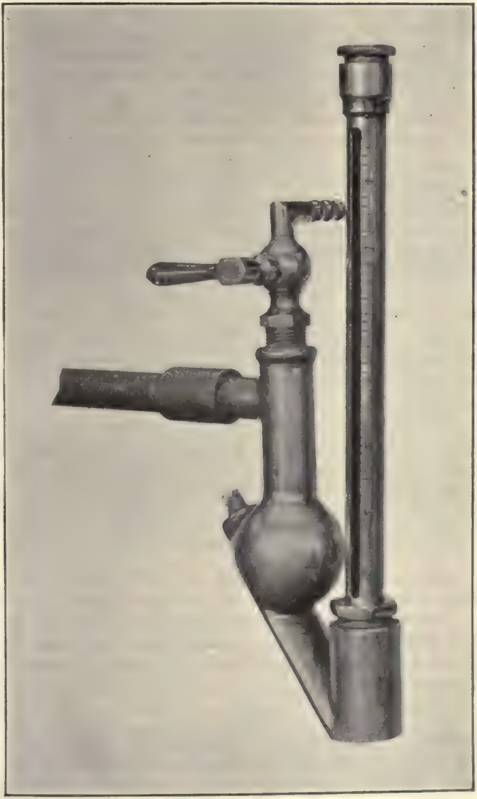


Figure 63. — Housepipe Inspection Gauge, page 195.

ished, and tempered carefully. The 6-inch size is best suited for general burner work.

Combination

These pliers, D, Figure 62, should be drop-forged steel, nickel-plated, polished, tempered carefully, and all parts interchangeable. The tool is a combination of regular plier, wire cutter, and screw driver. By a quarter turn of the handle, and by sliding from one point to another, an unusual capacity is obtained. They are made in various sizes, but the 6-inch size is best adapted for general use, and will grip up to $\frac{3}{4}$-inch pipe inclusive.

Gas

These pliers, E, Figure 62, should be made of good steel forging, polished, and have easy working joints. The 8-inch size is best adapted for general use.

Compass Saw

This saw is used in taking up floor boards, cutting holes in floors, ceilings, etc. It has a blade 12 inches long, which, from a width of 1 inch at the handle, tapers to a point. The handle is made of wood, and is interchangeable.

Screw Drivers

Two sizes of screw drivers are useful, both with wooden fluted handle, the small one being 3 inches long, and the large one 6 inches long, with the steel blade extended through the handle.

Wrenches

Alligator

This wrench is made of good steel, with a V-shaped opening at one end. One side of this opening is grooved like the ordinary pipe-wrench jaw, and the other is smooth. The jaws are tempered to be hard and tough. The 9-, 15- and 21-inch sizes are best for general use.

Strap

This wrench, F, Figure 62, is drop-forged from steel, with a linen band or strap, which grips firmly without marking. It is used on any polished pipe, and is made in two sizes, the 12-inch wrench taking pipe from $\frac{1}{8}$ to 2 inches, and the 18-inch size, from 1 to 5 inches.

Housepiping Inspector's Pressure Gauge

Figure 63 shows a gauge light and compact, but substantial enough to stand rough handling. The body is made of aluminum. It requires very little mercury, and loss of the latter through either the connection to the fixture or the top of the glass gauge, is rendered difficult, if not impossible. In the former case, a perforated metal pin, and in the latter case, a metal cap is the device employed. The cap is kept screwed hand tight upon the top of the glass gauge tube, except when the gauge is in actual use.

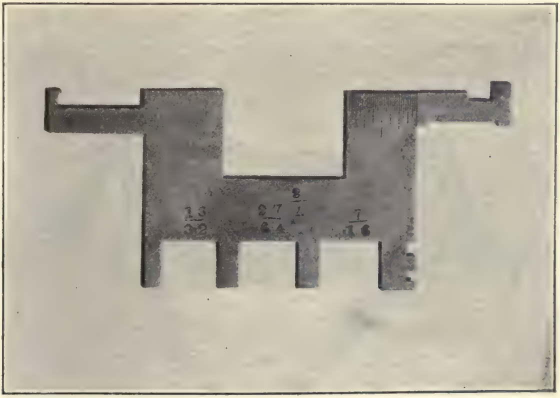


Figure 64. — Fixture Key Gauge, page 195.

Fixture Key Gauge

This gauge, Figure 64, is made of hardened sheet steel $\frac{1}{32}$-inch thick, about $3\frac{3}{8}$ inches long by $1\frac{1}{2}$ inches wide, and is used to test fixture cocks for compliance with specifications. Slots and projections are provided, by means of which it is possible to determine quickly whether the barrel has correct dimensions, pins are standard, seal is sufficient, etc.

CHAPTER XXI

MAINTENANCE AND MISCELLANEOUS EQUIPMENT

Complaint Kits

These kits are carried by men who go out on general complaints and turn on and off work.

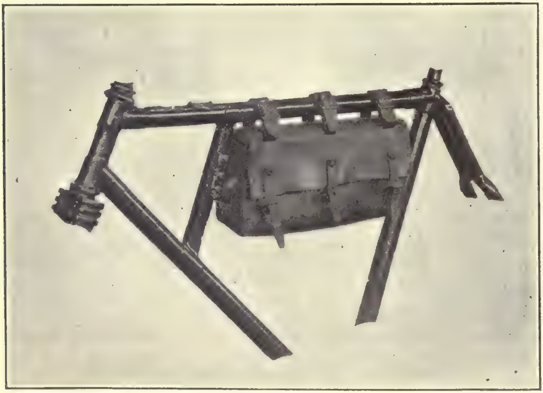


Figure 65. — Leather Bag Kit, page 196.

Leather Bag

This kit, Figure 65, consists of a leather bag, 12 inches long, 6 inches high, 4 inches wide at bottom, and $2\frac{1}{2}$ inches wide at top. The bag has straps for attaching to a bicycle frame, and straps are also provided on the flap so that tools can be put in or taken out without removing the bag from the bicycle. It contains the following equipment:

1 Meter Test Cap, 3- to 20-lt. inclusive,
1 " " " 30- to 100-lt. "
1 $\frac{3}{8}$-inch Cold Chisel, 6 inches long,
1 3-inch Screw Driver,
1 6-inch Knife Blade File,
1 Reamer Chuck Handle,
1 pair 6-inch Combination Pliers,
1 Small Meter Column Pump (strapped to outside),
1 set (6) Stove Reamers,
1 10-inch Trimo Wrench,
1 18-inch " " (handle cut down),
1 small box Stove Cement,
1 " " Key Grease,
1 " " Soap,
Supply of Stove Bolts, assorted sizes,
" " Caps, 1, $\frac{3}{4}$, $\frac{1}{2}$ and $\frac{1}{8}$-inch,
" " Plugs, $\frac{3}{4}$, $\frac{1}{2}$, $\frac{3}{8}$, $\frac{1}{4}$ and $\frac{1}{8}$-inch.

Tin Box

This kit, A, Figure 66, consists of a tin box, $2\frac{1}{2}$ by $6\frac{1}{2}$ by 13 inches, which opens and closes like an old-fashioned valise, and is provided with racks for holding the equipment. The box has a handle and shoulder straps, and contains about the same equipment as the leather bag kit, with the addition of a rack for cards.

Stove Repair Kit

These kits, B, Figure 66, are carried by men who go out to repair gas appliances, and the leather bag is the same as used by the complaint men, and contains the following equipment:

1 Meter Test Cap, 3- to 20-lt. inclusive,
1 $\frac{3}{8}$-inch Cold Chisel, 6 inches long,
1 6-inch Screw Driver,
1 12-inch Half-round File,
1 6-inch Rat Tail File,
1 Reamer Chuck Handle,
1 Ball Pein Machinist's Hammer,
1 pair 6-inch Combination Pliers,
1 Stove Bolt Punch,
1 set (6) Stove Reamers,
2 14-inch Trimo Wrenches,
1 small box Stove Cement,

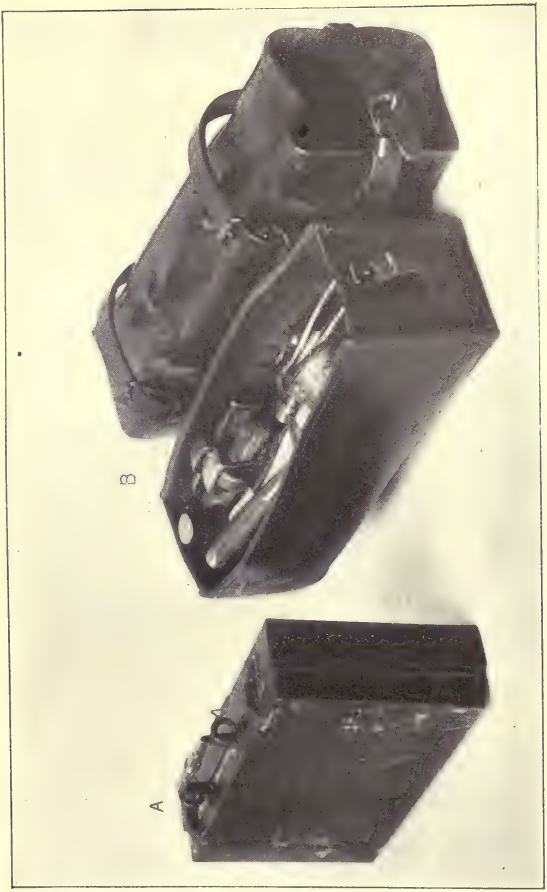


Figure 66. — A, Tin Box Kit, page 197. B, Stove Repair Kit, page 197.

1 small box Key Grease,
1 " " Soap,
Assorted lot of Stove Bolts and Nuts.

PLUMBER'S GASOLINE FURNACE AND KIT

The furnace, Figure 67, consists of the ordinary hot-blast, plumber's coil furnace, with one jet, and a gasoline capacity of one gallon. The kit contains the following equipment:

Figure 67. — Plumber's Gasoline Furnace Kit, page 199.

1 Tap Borer,
1 Dresser,
1 Shaving Hook,
1 Bending Iron,
1 Large Pouring Ladle,
1 Small " "
1 Turn Pin,
1 Rasp,
Drift Plugs.

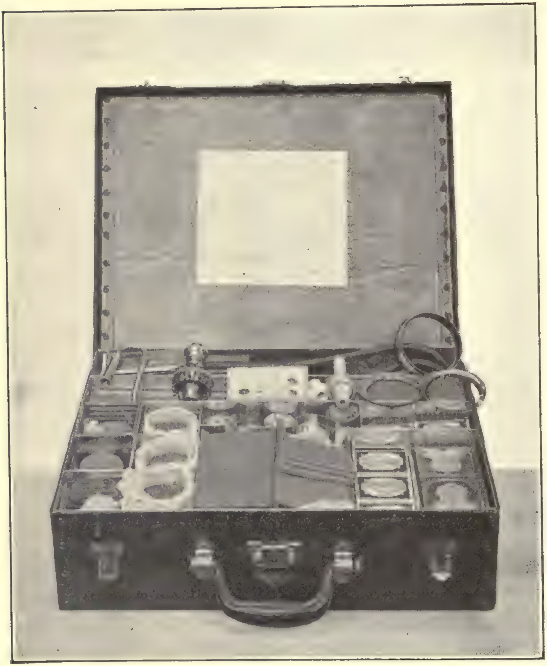


Figure 68. — Incandescent Repair Kit, page 200.

Incandescent Repair Kit

This kit, Figure 68, consists of a substantial composition fibre case, with hinged lid, handle, lock and catches, and has inside

dimensions as follows: Width, $19\frac{3}{8}$ inches; height, $14\frac{5}{8}$ inches; and depth, $4\frac{1}{2}$ inches. It is divided into various sized compartments by tin partitions, so that the material can be packed more easily, and, at the same time, breakages reduced to a minimum. The stock of material carried will vary according to the type of incandescent lighting installed. For Philadelphia conditions, the following equipment is needed:

1 #3 Bunsen Base,	10 Reflex Mantles,
1 #71 Burner,	5 500 "
5 #90 Burner Tips,	5 199 "
1 #4 By-pass,	3 197 "
3 #6 By-passes,	1 196 "
1 86 Chimney,	2 403 "
1 981 "	12 758 "
2 306 "	1 #36–38 Shade Ring,
1 310 "	3 Humphrey Tips (old style),
3 320 Cylinders,	3 " " (new style),
2 376 "	3 #4 Pilot Tubes,
1 #15 Cylinder Ring,	6 #6 " "
1 #1 GT Gooseneck,	3 #739 " "
1 #1 Mixing Chamber,	1 6-ft. piece Green Baby Tubing.

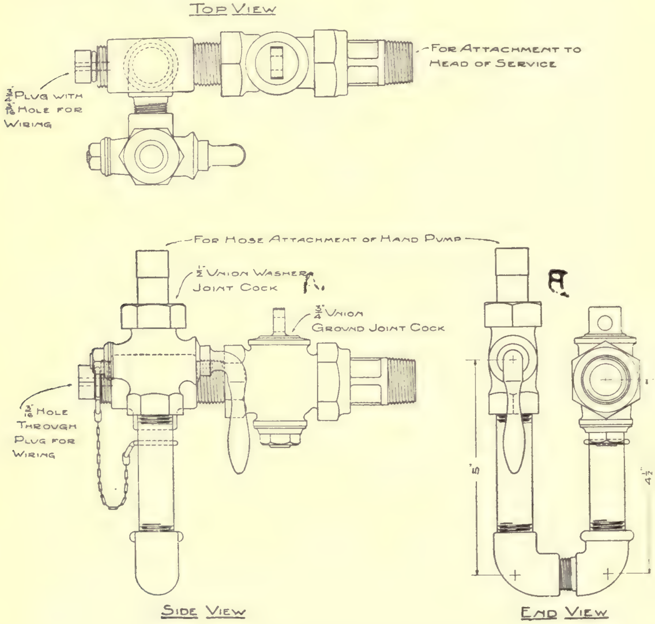
Service Cleaning Device

This is a device, Figure 69, with the use of which it is safe for one man to clear out services. It is made of $\frac{3}{4}$-inch fittings, nipples and cocks.

Force Pump

The term "force pump" as here used, has reference to the ordinary type of hand air-pump and the storage tank to which it is connected. This device is used in blowing out obstructions in services, lamp risers, and housepiping, and a convenient form, A, Figure 70, for all kinds of work consists of a light cylindrical brass tank, 18 inches long and 6 inches in diameter, with an ordinary hand air-pump mounted at one end, having a $1\frac{1}{2}$-inch cylinder, about 12 inches long. The body of the pump is in the tank, and the outlet has a check to prevent the compressed air escaping back through the pump. At the outlet of the tank is placed a $\frac{3}{4}$-inch lever-handled union cock, to which is attached about 6 feet of $\frac{3}{4}$-inch heavy rubber hose. A leather strap is

attached to the tank, so that it can be easily carried over the shoulder, and lugs are provided at the bottom of the tank to hold it firmly while pumping.



SERVICE CLEANING DEVICE

Figure 69, page 201.

Meter Column Pump

This is a hand pump, B, Figure 70, for clearing water or condensation out of meter columns. The pump cylinder is made of $\frac{3}{8}$-inch brass tubing, with handle and piston rod of $\frac{1}{8}$-inch wire. The piston is a thick leather washer, held by nuts screwed on the

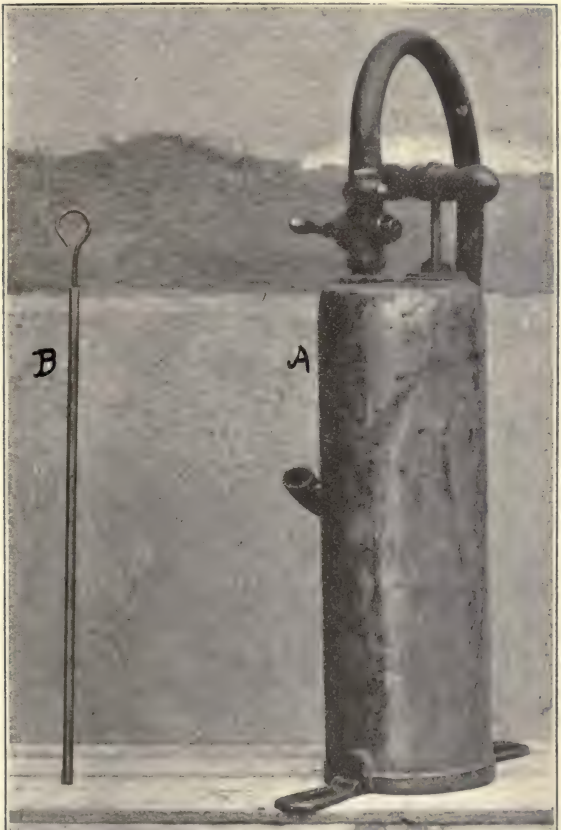


Figure 70. — A, Force Pump, page 201. B, Meter Column Pump, page 202.

end of the piston rod. The length of the pump for general use is 18 inches. If it is necessary to tilt the meter, the inlet side should be kept lower than the outlet side.

Transportation Work

General

While describing equipment, it is thought advisable to say a few words about the various types of vehicles used by a distribution department, with especial reference to the kind of motive power.

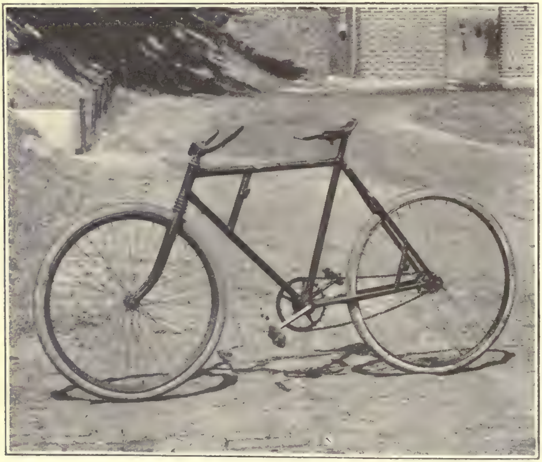


Figure 71. — Bicycle, page 205.

Bicycle

The bicycle is peculiarly adapted to the conveyance of men carrying little or no material, where the territory to be covered and the distances between stops do not make the motor cycle more desirable, all things considered. In Philadelphia, about four hundred wheels are in use by messenger boys, fuel appliance fitters, complaint men, inspectors, street gang foremen and

linewalkers. A commercial wheel will suffice for the boys, but experience has shown that for the men a more substantial construction is required, and in Philadelphia this need has been met by building a special wheel. Figure 71 shows this bicycle as made for a stove fitter. For inspectors and linewalkers, who carry no material, the front brace is omitted.

The total annual cost of a bicycle is about $38.00. (All of these transportation costs include depreciation and interest, and exclude wages of rider or driver.)

Motor Cycle

The motor cycle has, as compared with the bicycle, the advantages of saving time and exertion for the rider, and the disadvantages of greater expense and accident hazard. Philadelphia, after an experience of 10 years and now involving 71 motor cycles, believes there is a legitimate use for the motor cycle; primarily, for foremen and inspectors, whose duties if using a bicycle would involve more physical exertion than would be compatible with an alert mind, and, in general, to replace the bicycle for all employees whose work is such that the greater speed of the motor cycle affords a saving to balance its increased expense. The total annual cost of a motor cycle is about $240.00. Figure 72 shows the motor cycle used, — a 5-h.p., chain drive, single-speed machine, with kick starter.

Side Car

Whenever there are many small articles to be delivered to consumers, such as mantles, glassware, small lights or fuel appliance parts, economy demands their conveyance by something lighter than a single-horse wagon or the smallest gasoline chassis available. This is true especially when these small articles are to be installed by the man who delivers them, thus increasing the idle time of the vehicle. Philadelphia began to face this question in the fall of 1909, and tried to solve it by the purchase of motor vans, — tricycles with a box in front supported between two wheels, the rider sitting behind the box. Unfortunately, there was not a sufficient general demand for this type to develop a proper design and workmanship, and although at one time 25 vans were in use, the incessant breakdowns and the difficulty and expense of making repairs, caused the abandonment of the van in May, 1916. The annual unit cost was about $400.

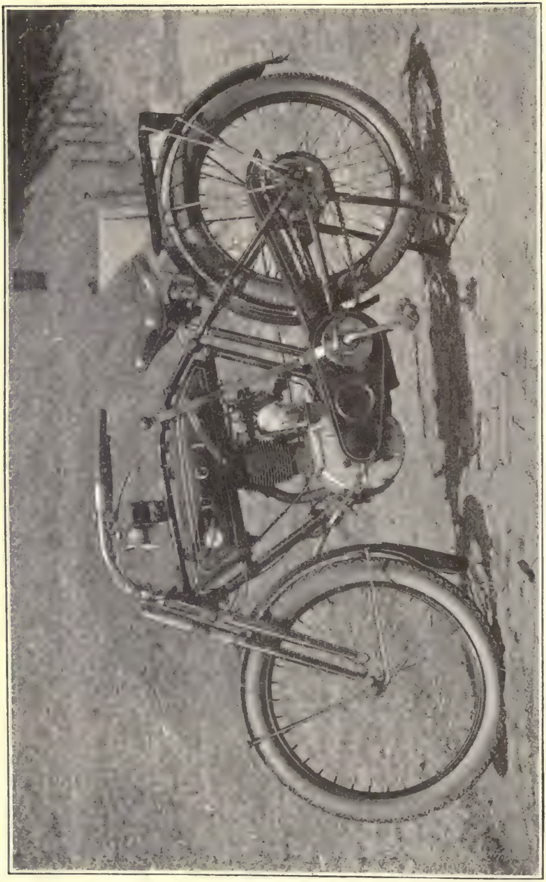


Figure 72. — Motor Cycle, page 205.

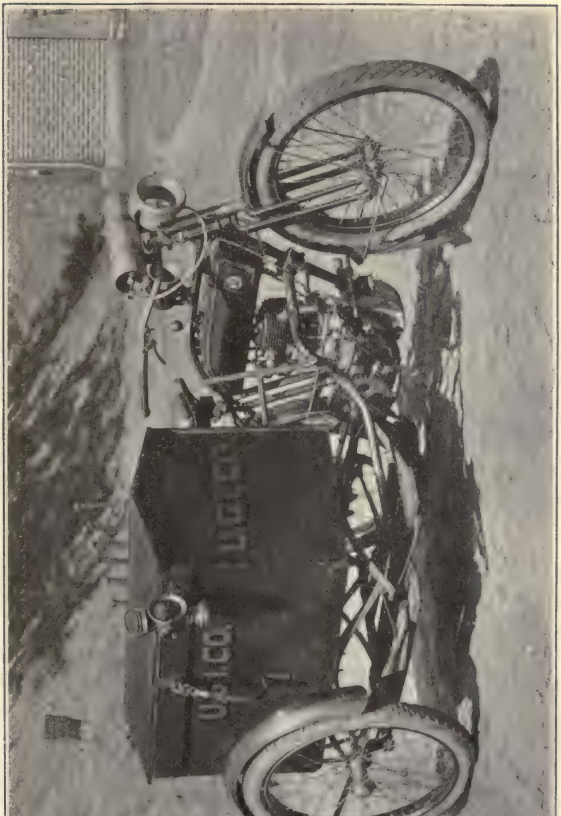


Figure 73. — Side Car, page 208.

Happily, just before the impossibility of van operation became evident, a substitute was found in the side car, which is a box attached on one side to a motor cycle, and supported on the other by an outlying wheel. It is shown in Figure 73. The box is 3 feet 4 inches long, 1 foot 10 inches wide, and 1 foot 10 inches high, with hinged top. The motor cycle is 5 h. p., chain drive, three-speed, with a kick starter. Philadelphia now has 30 side cars, most of them about a year old. There is a certain amount of breakage in the frame attachment, but it is hoped that this will diminish as experience leads to improved design. The annual cost per unit does not exceed $300, and the road troubles are very much less than with the motor van.

Horse Wagon

At present horses are employed for all of the four-wheeled transportation in two of the five Philadelphia distribution districts, and for general trucking, such as steel and cast iron pipe hauling throughout the city. Figure 74 shows one of the wagons used on district meter work. Its equipment is described in Chapter XLIX. The body is 10 feet 5 inches long, 4 feet 2 inches wide, and 5 feet 4 inches high over all. The annual cost per horse and wagon is about $940. There are about 46 wagons in constant use.

Gasoline Wagon

After using the motor van for two years to deliver light material, Philadelphia saw a use for a small four-wheeled wagon to replace the van in territory where paving conditions were especially destructive to the van construction. So in 1911, two small chassis were bought, and panel bodies added. A year later, a Ford wagon was purchased for combined meter and appliance work. Now there are 22 gasoline wagons employed in a variety of ways. One district is on a gasoline basis entirely, and in two others gasoline wagons are used in connection with electric wagons. All of the hauling to and from the main storeroom is also done by gasoline trucks. In the districts it has been found that the Ford chassis is too small and light for meter work, and too light for even appliance work. For meter work, a $\frac{3}{4}$-ton chassis is now standard, and for appliance work, a $\frac{1}{2}$-ton chassis. Figure 75 shows one of the latter wagons. The body is 7 feet 11 inches long, 3 feet 10 inches wide, and 5 feet high over all.

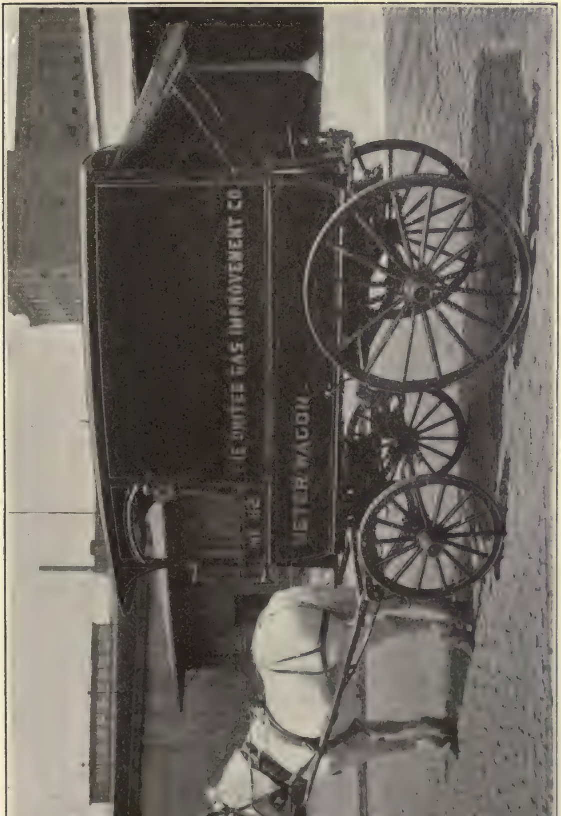


Figure 74. — Horse Wagon, page 208.

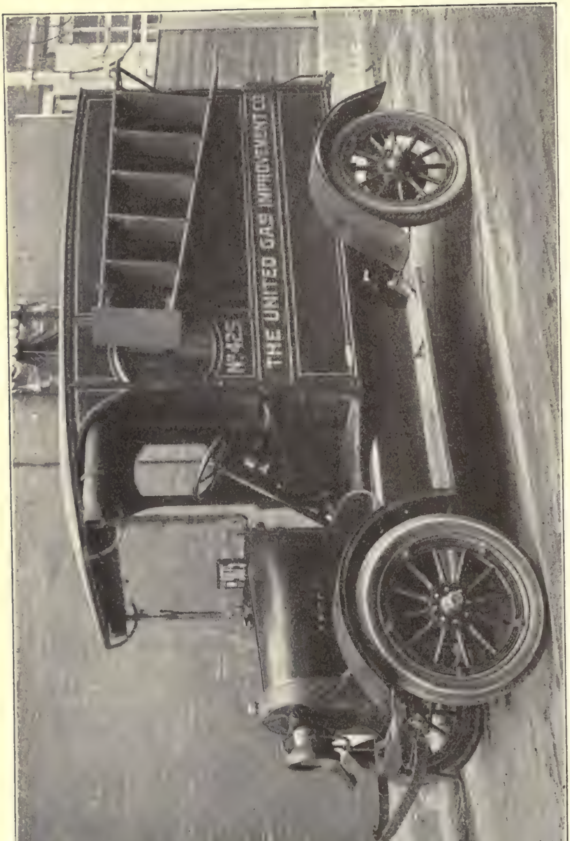


Figure 75. — Gasoline Wagon, page 208.

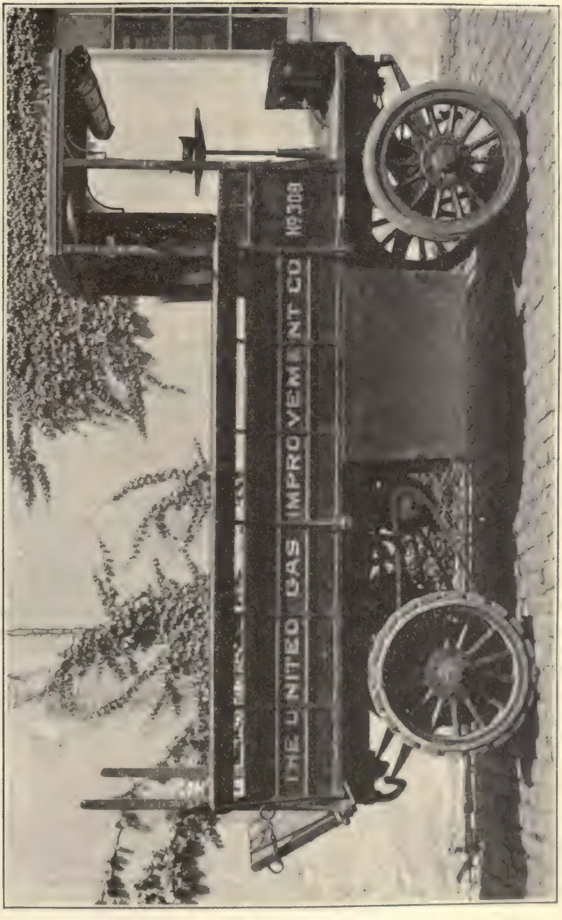


Figure 76. — Electric Wagon, page 212.

The annual cost of a gasoline wagon, as based principally upon a Ford chassis, is $1000. This cost will probably not increase as the slightly larger wagons replace the Fords, because the decreased cost of repairs will offset the increase in the other operating costs.

The universal substitution of motor for horse transportation in distribution work, has been delayed not only because of the higher first cost and uncertain performance of motor units, but also, as these factors tended to diminish in importance, by the small time in motion of the wagons used on meter work, this decreasing materially the economy accruing through the greater speed of the motor unit. Now, however, as the cost figures show, there is little difference between the horse and the gasoline motor, and when they further take into account the question of housing space, many companies probably will change to the motor, for they will find, as has Philadelphia, that with the great increase in transportation units accompanying new business activities, it is a choice between enlarging present horse stables, or, at much less expenditure, converting them into garages of ample size for some time to come.

Electric Wagon

Philadelphia bought its first electric wagons in 1909. By the use of motor wagons, a large expense for a district stable was avoided, and electricity was preferred to gasoline, because it meant a great saving in fire insurance premiums, and because at that time gasoline motor wagons were very unreliable and short-lived. An experience of seven years with 17 wagons shows that they are very satisfactory on good paving and slight grades, but that on bad roads and hilly territory, battery capacity frequently is lacking. The cost per wagon per year is $1500.

Figure 76 shows a 4000-pound wagon used for delivering ranges and main and service material. The body is 14 feet long, 4 feet 10 inches wide, and 3 feet 2 inches high.

PART IV

MAIN WORK

Under this heading will be described in great detail the proper organization for a street main force, and the right way of performing the various operations connected with the installation, maintenance and repair of a system of street mains.

SECTION I

INSTALLATION

CHAPTER XXII

ORGANIZATION

Small Towns

The proper organization of a force for the work of main laying will vary according to local conditions, as the sphere of operation is, first, in a small town, or the growing fringe of a large city; or second, in the congested portion of a large city. It also will vary somewhat in any particular locality, with the length and size of the main being laid, whether small, viz., 12-inch or under, or large, viz., 16-inch or over. [In the future, the words small and large will be used in this sense when referring to main work.] In any event, the street main work should be under one man, who, whether the superintendent himself (as would be the case in many companies) or not, will be considered for our purpose as being called the general main foreman, and will be referred to as the main foreman.

In the first case spoken of above, viz., a small town, or the growing fringe of a large city, the duties of the main foreman will be very general. He will make a prior inspection of all locations where work is to be done, plan the work, decide perhaps upon the character of the specials to be used, and arrange for their delivery as well as all other material, exercise a general oversight while the work is being done, and inspect the site after completion. In some instances, he will act as timekeeper and also check any reports made out by the gang foreman.

If the work consists almost entirely of laying mains to supply row after row of houses, or, as they are sometimes called,

"building operations," as the majority of these operations are begun in the spring and finished in the fall, and the most economical organization of the main force is that of a constant number of men, able, by working 300 days in the year, to lay the miles of mains required annually, then, in order that the main and service work always shall be finished when gas is needed, or, as is more usual, when the builder is ready to pave street and footway, it often becomes necessary to lay a main in some streets soon after the house foundations are begun. It should be said here, however, that the gas main preferably should follow the laying of the sewer and the water main. This early laying will mean sometimes that the proper line and grade stakes must be obtained from the city surveyor, and then the main foreman takes the gang foreman to the location and gives him, with reference to the stakes, all the information necessary in regard to opening trench. The two foremen also decide upon the best starting point and any other details in regard to the work, such as the proper character and location of the necessary specials, including drips, for under the conditions being described, there will be few underground structures encountered to cause unexpected changes in plan. As mentioned before, the delivery of this and any other material, and of tools and equipment, will come directly under the supervision of the main foreman, and if the team used is employed also in hauling material for service work, the main foreman will make all his plans for this team in conjunction with the service foreman, in order to insure its most economical use each day.

Where the recording of main work is done by the main department, the main foreman generally will make the necessary sketches, assisted by the gang foreman for such portions of main as may be laid and covered up in the absence of the main foreman.

To sum up, in the conditions now being described, the main foreman plans the movements of, and lays out in detail, the work of each main gang, and the gang foreman handles his men to get the designated work done with the greatest possible despatch and efficiency.

The composition of each individual gang will depend largely upon local conditions. For the Philadelphia work, in the growing fringe, where most of the laying is 6-inch in dirt streets, and the average job is one block, or about 500 feet, the following personnel has been used to great advantage:

1 Gang Foreman,
2 Caulkers,
2 Caulkers' Helpers,
14 Laborers.

In warm weather, a water boy will enable the men to keep steadily at work, and not be continually leaving the trench to walk to the water pail.

Experience has shown that with a good organization and a competent foreman, a small gang of this kind will turn out a splendid amount of work per man. Each laborer becomes a picked man and is worth the extra pay he gets. It is also surprising, if the proper brains be directing the main work, how well a constant force may take care of what would seem to be a very fluctuating amount of building operations, as measured by the number begun each month. It is needless to say that where a gang is changing continually in size throughout the year, the output per laborer is lessened appreciably.

Large Cities

The second case spoken of at the beginning of this chapter, viz., where the sphere of work includes the congested portion of a large city, necessitates a change in the mode of working and more of an organization. The main foreman's duties will be largely executive, and he can have little detail work to do, as he must be free at all times to go where needed. He often will have to confer with the officials of other companies when changes in locations of gas mains or other structures are in question, or cases of interference or damage have arisen. So much of his time will be taken up in this way that he cannot have very intimate relations with the gang foremen, or lay out their work in detail. He must train these foremen to decide for themselves in ordinary cases. As he cannot follow any regular daily routine in his work, he should always keep in touch with his office, so that he can be reached quickly if necessary.

The gang foreman, it will be readily seen, should be of a higher type than is needed in situations where the main foreman looks after much detail. While the main foreman will have direct charge of the material delivery teams, the gang foreman will determine the material wanted and its time of delivery. These orders usually will be telephoned to the office for approval by the main foreman, who, because of his knowledge as to the exact conditions of all his work, is able best to decide upon the details

of their execution. Inasmuch as the careful routing of such orders as to distances traversed by heavy or light loads, does not appeal to the average driver, the main foreman often is able, by good routing, to decrease considerably the work of his teams. Beside knowing how to handle his men efficiently, the gang foreman must possess good judgment, not only in ordinary routine work, as, for instance, in regard to the amount of trench opened ahead of pipe laying, but also in meeting any peculiar conditions that may arise in the absence of the main foreman. Instant action may be necessary to prevent loss of life, or damage to property, and the gang foreman should be able to act quickly and have a fertile mind and ability to reason carefully. When the gang foreman is not stationed for the day at any one particular location, he should keep the office in touch with his movements, preferably by telephone.

Neither the main foreman nor the gang foreman should be expected to make any sketches of the work done. To avoid all possible chance of misunderstanding, no job should be done except upon a written order issued by the office and accompanied by a sketch giving in detail all available information necessary for the work.

The personnel of each main gang should be of a fairly high type, especially in caulkers and helpers, because the obstructions encountered and the heavy street traffic make pipe laying difficult. This would be the gang used:

1 Gang Foreman,
4 Caulkers,
4 Caulkers' Helpers,
16 Laborers.

In especial cases of tedious or dangerous work, the whole gang should be composed of experienced men.

For small jobs of changing mains, where backfilling follows immediately upon laying, such as laying around manholes, the gang would be as follows:

1 Gang Foreman,
3 Caulkers,
2 Caulkers' Helpers,
1 Laborer.

CHAPTER XXIII

PRELIMINARY WORK AND REMOVING PAVING

Preliminary Work

Preinspection of Site

To insure continuity of work for a main gang, it always is necessary to have planned out ahead, jobs covering a week or ten days. A preinspection of each street is essential to ascertain what obstructions may exist along the proposed line of main. Where a building operation is in progress, there are often piles of building material, mortar bed, plaster bed, etc. By giving the builder some days' notice of the time for beginning work, he will, especially if he is anxious to have the main laid, arrange to have a clear path for the trench. It often is necessary, however, to see various subcontractors and to make several calls, and, if possible, the gang should not be shifted to any location until all obstacles are out of the way.

At this point it will be well to speak about one phase of preliminary work in connection with large main laying, that is peculiar to congested conditions, viz., the ascertaining whether, at the location given for the trench, sufficient space will be found. Generally, before a permit is asked for from the city, or perhaps before a route is laid out for the main, test holes have been dug to ascertain the exact location of the existing underground structures. The frequency of these holes, and their extent, will vary, depending upon the conditions found. If it is apparent that there is plenty of available space, few test holes will be needed. If, however, conditions are very congested in the route and at the location finally decided on, then, unless the preliminary test holes were within 100 feet of each other, it is advisable at some time before actually beginning the work with a large gang, to open a series of test holes covering two or three blocks, and thus definitely determine the exact location of the trench. It happens sometimes that this will be a zigzag line.

As the work progresses, test holes may be opened for the rest of the route. It always is advisable to do this test hole work well in advance of the necessity for trench opening, especially if a change in location requires an application to the city. In length, the test hole should, of course, cover the space to be explored, and in depth, it should equal the probable depth of trench required. In addition, a bar should be driven down several feet at various points in the bottom of the hole to make sure that no structure lies beneath. This driving should be done slowly and with great care, to avoid damage to any structure.

Delivery of Material

The delivery of material, such as pipe and specials, also should be arranged for. When the force employed in main laying is fairly constant in size for several months, it is comparatively easy to estimate the weekly or monthly need for pipe. As to the yearly need, it has been found possible to anticipate it very closely, and to place such orders with the foundries that carloads of pipe will be received as wanted, and more than 90 per cent of the lengths hauled directly from the car to the street. This makes for great economy in handling.

In stringing the pipe, if 12-inch or larger, it should be left with bells all pointing the same way, viz., in the direction in which the main will be laid. This direction should be whatever local conditions make most convenient, except where there is a grade exceeding 5 per cent, in which case the bells always should point uphill, reversing direction at each low point and summit. When the pipe is smaller than 12-inch, it does not pay to add to the expense of loading and unloading by requiring one direction of bells. Pipe should not be dropped off the truck to a paved roadway, but upon wooden blocks or rope mats provided for the purpose. The pipe should be strung as closely as possible to the curb, and on the side of the future trench, except in the case of large pipe, when the trench is some distance from the curb and the excavated material will occupy all the space between curb and trench, so that the pipe must be rolled across the street as needed. Under ordinary city conditions, where the street is open to travel, the pipe must be lamped properly each night.

In addition to the pipe, certain special castings may be delivered on the street prior to beginning work. This is more apt to happen with large mains than small ones, for in the former case, there often are opportunities to economize by hauling the

specials directly from the car, while the small specials, being ordered in large quantities, usually before the beginning of active main laying, are at the various storeyards. Also, a large main job implies, as a rule, a length of a thousand feet or more, and the use of a minimum number of certain specials, no matter what may be the underground conditions. This is not true of the average 6-inch job under Philadelphia conditions, where, if laying from an intersection already in place to the other end of a block, beyond which the development is uncertain, there may be no specials of any kind required. Again, if an intersection is to be laid, it may be known what tees and crosses are required, but the necessity for bends is uncertain, depending entirely on underground conditions yet to be revealed. Therefore, it may be frequently more economical to deliver no specials until the exact needs of the job are known.

Concerning miscellaneous equipment, such as blocking, cement, lead, etc., it is a mistake to have on the street any more than is necessary to furnish economical hauling conditions from the storeyard. Beside the danger from theft, every pound of material left over on a job, to be transferred to the next site, involves unnecessary hauling expense. Where cement is used, the more on hand, the more chance of spoiling from storms. One method of caring for small lots on the average job, where a shelter shed is not justified, is to pile the cement bags on the wooden blocks, high enough to be out of possible wet, and then cover over with a water-tight canvas.

Nature of Equipment

The normal equipment for a main-laying force depends, first, on its size; second, on the character of the main work, including the kind of jointing material used; and third, on condition of paving and weather (winter or summer). The equipment listed below can be carried in the large service cart described on page 176, and will suffice for the force described on page 217 when laying 4-, 6- or 8-inch pipe. For larger mains, additional equipment will be necessary.

2 4-inch Bags,	2 4-inch Wooden Plugs,
2 6-inch "	2 6-inch " "
2 8-inch "	2 8-inch " "
1 Leak Bar,	1 Bag Pump,
1 Rock Pinch Bar,	5 Rammers,
1 Search Bar,	6 Canvas Screen Rods,

2 Tunnelling Bars,
3 Pipe Brushes, 4, 6 and 8-inch,
1 Galvanized Iron Bucket,
1 Squirt Oil Can,
6 Cape Chisels,
6 Dog "
8 Crowbars,
1 Drinking Cup,
13 Asphalt Cutters,
2 Bag Forks,
1 Syphon U Gauge,
2 14-lb. Sledge Hammers,
1 Asphyxiation Kit,
10 Red Lanterns,
1 Small Pocket Level,
1 24-inch Level,
1 300-ft. Ditch Line,
1 Mueller Combination Tapping Machine, with drills,
1 Mattock,
15 Picks and handles,
5 Ditch Line Pins,
1 pair Combination Pliers,
12 Diamond Points,
2 Porters,
10 Lantern Rods (unless danger signs are used).
1 6-ft. Rule,
1 One-man Crosscut Saw,
3 Canvas Screens,
2 Flat Nose D-Handle Shovels,
13 Sharp " " "
1 " " Straight Handle Shovel,
15 Danger Signs,
2 4-inch Stoppers,
2 6-inch "
2 8-inch "
1 50-ft. Canvas Tape,
2 Ditch Targets (either type),
3 sets Caulking Tools,
2 Asphalt Wedges,
6 Concrete "
6 Frost "
3 Pipe-Bursting Wedges,
1 Plug Wrench,
2 14-inch Trimo Wrenches,
10 lbs. Yarn,
Assortment of Fittings and Nipples,
Soft Soap and Brush,
Tallowcloth.

FOR CEMENT JOINTS

1 Mixing Board,
1 bag Cement,
3 prs. Rubber Gloves,
1 Cement Sieve, 12-inch,
1 Trowel,

FOR LEAD JOINTS

3 Pouring Bands, 4, 6 and 8-inch,
1 Bellows,
1 Lead Furnace,
1 Pouring Ladle,
25 lbs. Lead.

Location of Equipment

When preinspecting the site, the location of such equipment as tool boxes (Figure 49, page 174), tool wagons (Figure 48, page 175), service carts (Figure 52, page 177), etc., usually is determined. When there is much equipment, a vacant lot is, of course, preferable to a roadway location. A footway location should be

avoided, unless the footway is wide and little traveled. Ordinarily, an available and suitable location is in the roadway of an intersecting street at an end of a one-block job, or near the centre of a larger job.

Preparing for Trench

The occasional necessity for line and grade stakes has been previously mentioned. It always is well to give the surveyor at least a week's notice. Where there are no curbs at either side of the street, or at the intersections, stakes are needed. If either side, or intersection, has curb set, by obtaining from the surveyor the width of street, whether straight grade through the block, and if not straight grade, the location and height of the summit, then, by means of tape line, level board, tees and targets, the height of curb, and, therefore, proper depth of trench, can be determined accurately enough for most jobs.

The trench is marked out for the width required for the size of pipe being laid, the schedule recommended being as follows:

Size	4″	6″	8″	12″	16″	20″	24″	30″
Width	18″	18″	18″	22″	26″	30″	36″	42″

If the street is paved, both sides of the trench are marked with colored crayon, yellow or red preferably. One way of doing this is to locate each side of the trench from the curb every hundred feet, and then stretch a line between each series of points, first on one side of the trench, and then on the other, marking along the stretched line. If there is no paving, a guide along one side of the trench usually suffices, being given by a rut marked by pick or shovel from a stretched line, or else the line may be left in place on the side opposite to which the excavated material is placed.

The pipe is lined up also on the opposite side of the trench to the proposed location of most of the excavated material. This ordinarily means that it will be on the side nearest the curb. In lining up, the bells should be pointed in the proper direction, and the pipe should overlap as nearly as possible the exact depth of joint. This will obviate any necessity for shifting pipe lengthwise along the trench. Of course, the larger the pipe and the longer the stretch lined at any one time, the more will be the possible saving by careful lining. Where the lining covers the entire job, any shortage or excess of pipe will become evident at once. Where on large mains the earth is thrown on the curb

side, and the pipe strung across the street, it may not be advisable to line the pipe, but simply to roll it across as needed.

Removing Paving

Separating Materials

On a paved street there usually are several classes of materials to be removed from the trench, and each class should, if possible, be kept more or less separated. Asphalt pieces, or paving blocks, are generally piled, often forming a retaining wall for any large quantity of earth excavation. Bricks or rectangular stone blocks are often of use in making channels for conducting water flow under excavated material. Sand or concrete is kept free from any contact with earth.

In the ordinary case of a small main, the earth would be thrown on one side, and the paving material and base on the other, and the latter might be allowed to lay where it fell, if not in sufficient quantity to interfere with laying operations. Where, as is always the case with large mains, there is surplus material to be hauled away, arrangements should be made for loading into wagons as excavated, in order to save rehandling. This direct loading is most economically done when the top excavation is so disposed of.

Occasionally a streak of gravel or sand is encountered, and if it is of value for repaving, or for other use, care is taken to keep it separate from the material. Where there is loose or solid rock, the pieces generally are thrown clear of the earth excavation, so they will not be covered over and can be easily hauled away.

Asphalt

In cutting asphalt, the asphalt screen (Figure 8, page 105) always should be used where there is any danger of injury to property or persons from flying chips. As a rule, only one side need be screened, viz., that toward the footway, but if the trench is near a car track with much traffic, and open cars are in use, the track side will need a screen. Support for the screen is obtained by the rod (A, Figure 7, page 104) and sometimes by tying to trees or poles.

Each cut is made by two men working together, using asphalt cutters (D, Figure 7), one cutting right, the other left, and the line marking the side of the trench forming the centre of the cut.

Each pair of cutters is spaced 8 feet apart, the first pair cutting the right-hand line, the second the left-hand line, etc. This staggering of the cutting work enables the whole gang to be closer together, and, therefore, under better supervision by the foreman. With a gang of not more than twenty men, it is advisable to place at cutting work, all the men that tools or space will allow, and finish this work quickly. In any case, after all the cutting is finished, one man is given a regulation street broom to sweep up all the chips, both those inside the screen and any that may have passed over the screen and lodged on footway or roadway.

If the asphalt is on a concrete base, after both sides are cut to the base, the asphalt can be lifted off with bars (B, Figure 7), each lifting gang being composed of four men, viz., two men using the bars, one breaking the asphalt to pieces with a 14-pound sledge (E, Figure 9, page 106), and one man carrying away the pieces. As many gangs may be set to work as the width or length of trench will allow.

If the base is a rock or bituminous one, the asphalt is removed as follows: Asphalt wedges (A, Figure 9) are driven in at the bottom of the cut toward the center of the trench, at an angle of 45° with the paving. Four wedges, all on one side, spaced about 12 to 15 inches apart, are used at one time, being driven in for at least 6 inches, and then loosened by hitting down on the upturned face of the wedge. At the same time, the asphalt is sledged on top at about the centre of the trench. Then the wedges are withdrawn, bars placed in the holes thus left, and the asphalt raised. With the width of trench as opened for small pipe, ordinarily all the asphalt can be thus raised from one side. If not, or on wider trenches, the same procedure of wedging and sledging must be followed on the other side of the trench. It often is advisable to begin to wedge up another section of asphalt before raising all the asphalt that has been loosened. By leaving in the last wedge, a better purchase is obtained on the next section. The gang is composed of six men, three handling the sledges and wedges, one alternating between the bar and the sledge, and two removing the asphalt pieces. At times, the three using the sledges will aid on the bar in prying up the asphalt.

On a bituminous base, where the distance between cuts is, say, over 2 feet 6 inches, the pinch bar (A, Figure 17, page 120) often

may be used to better advantage than the paving bar (B, Figure 7) in lifting the asphalt after it has been loosened.

The asphalt, once loose, is broken up with sledges to a one-man size and piled preferably on the footway along the curb, in heaps about 2 by 4 by 3 feet high, with centers 12 feet apart.

When the trench is both long and wide, as for a long line of large main, a steam roller, equipped with knife and breaking points, may prove more economical than hand labor for cutting and breaking up asphalt. E, Figure 7, shows the tool used to cut asphalt with the aid of a power tamping machine.

Other Paving

Where there is vitrified brick, belgian block, asphalt block, rubble, cobble, or macadam paving, instead of marking the sides of the trench by crayon, as before described, an alternative method is to drive in ditch line pins (C, Figure 9) at points a hundred feet apart. Enough paving is removed to make room for the pins, which are driven into the paving at an angle of 45°, pointing out from the centre of the trench, until the head of the pin is almost flush with the paving. In this way the pins will not become loose as excavating proceeds. A line is stretched from pin to pin, forming the guide for paving removal and excavating.

For vitrified brick, belgian block and asphalt block, the removing gang is composed of one man barring out paving with the all-iron tunneling bar (C, Figure 13, page 114), one man standing in the trench, lifting the paving and throwing it toward the curb, and one man at the curb piling the paving material. For these classes of paving, and also asphalt, it always is best to remove paving by a special gang, and keep this work well ahead of the trenching, in order to avoid using the trenching force on removing paving.

For rubble, cobble or macadam, the trench is laid out in 12-foot sections, and each man removes his own paving with pick and shovel, throwing it off to one side of the trench, any additional moving and piling being done by separate men.

CHAPTER XXIV

TRENCHING

Preliminary Work

Protection of the Public

Preliminary to, and also coincident with, the opening of any trench, certain precautions are necessary for the protection of the public, of the workman in the trench, and of the latter itself. Local conditions will determine in each instance just how many of these precautions are required.

Traffic, both roadway and footway, across the trench, may have to be provided for. A footway bridge, in its simplest form, consists of one or two planks laid across the trench, battened together, and with a plank on each side to act as a guard. This will serve where the traffic is light and the job is of a few days' duration. In laying large pipe, or long lines of small pipe, where important streets are opened, the footway bridges should be at least 3 feet wide and have sides 3 to 4 feet high. These bridges are moved from point to point as the work progresses, and six may suffice for even the largest job. No matter what form of bridge is used, attention must be paid to each end becoming a cause of stumbling. Earth placed at the end will remove this danger and also hold the bridge in place.

Roadway bridges should be made from 3-inch planking. Cross pieces are placed across the trench about 2 feet apart, projecting fully 2 feet into each bank. Planks, parallel to the trench, laid on the crosspieces, form the floor of the bridge, which should be not less than 8 feet wide, as measured between the guard railing put up across each end. The floor of this bridge should, as far as possible, be level with the top of the street. Care should be exercised in making a good joint with the street surface at each approach to the bridge, and earth may be used to good advantage in this, especially where the bridge is somewhat above the paving.

Any trench for large pipe, or a trench for small pipe paralleling a car track, the excavated material in each case being on the curb side, should have a proper guard rail placed along the exposed side. This can be made by laying three or four pieces of 6 by 6-inch, or 8 by 8-inch, along the trench, about 12 feet apart centre to centre. To each piece a 1 by 6-inch, 3 feet long, is nailed as a post, and a 1 by 3-inch, or 1 by 4-inch, nailed to the top of these posts, forms a top rail. This rail is, of course, fairly flimsy, and will need bracing at intervals.

In excavating under car tracks, any paving between the tracks, and for the space of one foot outside each rail, should be first removed, and then 3-inch planks laid in this space across the trench parallel to the rails, and projecting 2 feet into the bank on each side of the proposed trench. These planks should be flush with the rail and, after they are in position, well secured by driving earth in tight at both ends of each plank.

In the provision of bridges, as well as in any other steps necessary to minimize the inconvenience to the public caused by main work, niggardliness is apt to be poor policy, and a proper appreciation and provision for the rights of the public is quite compatible with efficient and economical operation.

The exact requirements in regard to affording free access to fire hydrants probably will vary in different places. Certainly excavated material should be kept at least six feet from a hydrant, and access to it provided, both day and night, even if this means a bridge across the trench.

During the day the trench and all material should be protected by danger flags (E, Figure 13) and at night by lantern (F, Figure 13).

Protection of the Workmen

The principal source of danger to a trench worker, viz., a cave-in, generally is absent in gas main work, because of the shallow trenches usually sufficing. The ground, however, always should be watched carefully for cracks, and if, because of deep excavations, or unstable material (as when the trench lies close alongside a former trench), it is thought that the slightest danger exists, shoring should be employed. Usually a 2 by 12-inch stretcher, 16 feet long, in one or two lines, held apart by adjustable braces (Figure 14, page 116) will suffice. Where sheet piling is required, 1 by 12-inch boards may be placed back of two lines of stretchers. Naturally, where shoring

is resorted to, undue weight should be kept from the trench side, and this may mean in some cases a second handling of material to keep it back from the edge of the opening.

Protection of the Trench

Provision should be made to prevent any surface drainage flowing into the trench. Often such drainage must be conducted under the excavated material. At other times, damming will suffice to divert surface flow away from the trench. There is no duty of the gang foreman more important than to have his trench protected from the results of very violent rain storms. Where underground water is flowing into the trench, a sump hole should be made, and a cellar pump (A, Figure 16, page 118), or a block pump (B, Figure 16), placed in position. In most soils, the presence of water will be very disastrous to the trench sides, so the water must be kept down.

Under this head may be considered the necessity for marking at the trench side, the probable location of any water services crossing the trench. In each case the proper laborer should be shown the mark, and be cautioned to be on the lookout for the service when approaching the proper depth, in order to avoid any chance of injuring it.

Earth Excavation

For small mains, the ditch line and pins mark the side of the trench opposite to the excavated material. Each man measures off with his shovel a space of 12 feet, and is assigned this space for his work. This sectioning of the work affords an easy way of comparing the relative efficiency of each laborer. In each gang, it is advisable to have one or two men better paid than the rest and expected to serve as pacemakers. If conditions are alike along the trench, the gang foreman expects all the sections to go down equally fast, and in practice this pitting of each man against his fellows conduces to high efficiency.

For large mains, both sides of the trench are marked by a line. For mains up to 16-inch inclusive, the diggers are expected to throw the material far enough to render unnecessary any subsequent trimming. For 16-inch mains, the diggers are placed 12 feet apart, for 20- and 24-inch, 8 feet apart, and for 30-inch, 6 feet apart. For 20- and 24-inch no trimming is done until the excavation has been completed. For 30-inch, at a depth of 4 feet, it is necessary to place one man on the bank to trim the material thrown out by every two diggers.

On every job, special men, such as caulkers, or pipe layers, are assigned to open over the mains to which connection will be made, and over any places where obstructions are expected, the places above described being those which may disclose conditions affecting the depth of the trench, and which, therefore, must be known before any bottoming can be done.

The considerations affecting the amount of cover given to a main have been described on page 74. After the depth of trench has been fixed, the ditch targets (Figure 10, page 109, or Figure 12, page 112) are placed in position.

When working in frozen ground, one or more holes should be made through the frost, and then by using the frost wedges (B, Figure 9,) and barring off from the face thus made, the frozen ground can be lifted off much as would be a concrete base.

Rock Excavation

Where the rock may be removed by bars (C, Figure 7), wedges (D, Figure 9), and sledges (E, Figure 9), the men work in pairs in a section so as to give each other assistance. The small spalls are thrown with the dirt on the opposite side of the trench from the large stone.

Where blasting is required, three men form a gang, and the gangs work as close together as possible. One man holds the drill (C, Figure 17), and two men strike. The charging, covering and firing of the holes should be delegated to one man, who should be an experienced rock man. Upon this man's judgment will depend the placing of the holes and the charge used. In general, the attempt is to secure always a face extending the full depth of the proposed trench. By staggering the holes in the various rows, the best progress is made. On small mains where the rock is very hard, it is advisable to start with a width of trench twice that required for earth. This will allow for failure to blow out to complete width in places. Often, of course, the trench will widen still more from blasting.

All firing should be done from a battery (E, Figure 19, page 123). Before firing, great care must be taken to be sure that all workmen and the public are at a safe distance.

There should be a space of at least 4 inches between any solid rock left in the trench and the nearest point of the main as it rests on its blocking. This is necessary to minimize the chance of future breaks or leaks, due to later blasting operations when laying other structures.

CHAPTER XXV

LAYING MAINS

Organization for, and Details of, Pipe Laying

Large Mains

The trench having been excavated as described in the preceding chapter, is now ready for the pipe-laying gang. Before telling of its work, the complete organization for laying 20-inch and larger mains, will be here given as follows:

1 Trenching	Foreman	and 18	Men,
1 Laying	"	" 12	"
1 Back-filling	"	" 8	"

Better results are obtained by having one foreman over every separate gang, than are possible by attempting to work with only one foreman. If the general main foreman is not on the work frequently, authority in his absence should rest on one of the foremen, probably the laying foreman. The laying gang, if working steadily, would require more diggers and backfillers, but in practice, obstacles arise to interfere with laying, and, therefore, the laying gang is used more or less to aid the other gangs.

The laying gang contains 4 caulkers, or joint makers, and 8 pipe men. As far as possible, the various routine duties that arise should be assigned definitely to individual men, so that, as the work progresses, there is no confusion and each man becomes adept at his special task. The foreman lays out the bell holes and starts his gang on them, borrowing laborers from the trenching gang if necessary. Each bell hole extends from 3 feet in front of, to 1 foot back of the bell, clear across the bottom of the trench. Its bottom is 4 inches below the regular trench bottom, and its width, as measured along its bottom, is 20 inches greater than the trench width, tapering off to, and reaching, the trench width 15 inches above the proposed location of the pipe top. The material thrown out from the bell holes should be

trimmed back, and before laying starts, there should be a 2-foot passageway on the street on each side of the trench.

A dozen or more bell holes being completed, blocking is placed in position on the trench bottom. The "back" block is put with its near edge 1 foot back of the face of the bell, while the "front" block lies with its near edge 3 feet in front of the face of the bell. Back-filling will be reduced and the cavity under the centre of the pipe lessened if the trench has been so dug that the blocks may be set in the trench bottom so their tops will clear it not much more than 1 inch. This condition is difficult to obtain, however, and where there is insetting, care is necessary to ensure that the block rests on a flat, and not a concave surface. The back blocks are set by spanning from one set to another with a level board set for the determined grade of the main; or each back block may be set by using a target. The front block always is set a little lower than the back block so the main will just clear it.

The pipe, having been previously cleaned on the inside by the circular brush (A, Figure 21, page 126), and all dirt and scale carefully removed from the inside of the bell and the outside of the spigot end by a wire brush (B, Figure 20, page 125), is rolled in position on the skids spanning the trench. The derrick (Figure 23, page 130) is so placed that it will lower the pipe into the position desired. When moving the derrick, one man is at each of the rear legs and two men at each of the front legs. (The front side is that side on which the winch is located.) When in position and in use, the four men on the front side remain there, but the two men at the rear legs are available for other work. The sling (page 128) is adjusted so that the spigot end will be slightly heavier than the bell. The pipe is raised until the bell end clears the front skid, which is removed by the proper man while another man bears his weight on the bell, thus causing the spigot end to clear the rear skid. This in turn is removed and the pipe lowered. While the pipe is swinging clear in the sling, the laying foreman should sound it with a hammer as a means of detecting any flaws or cracks which may not have been detected by previous inspections. A fine crack is overlooked so easily and the removal of a cracked length from a line of large pipe is so costly, that time spent in careful sounding is true economy, and a good laying foreman will never let a crack or flaw escape him. All specials and small pipe are sounded shortly before they are laid.

If, because of obstructions, the pipe cannot be lowered at the point where it is to be laid, then it must be moved along the bottom of the trench by successive shifting of the derrick; or if the use of the derrick is not possible, the pipe is lowered upon a timber truck and rolled into position over a board platform laid on the trench bottom.

While the pipe is being lowered, there are two pipe men in the trench, one in front of the bell end of the length being lowered, and one just back of the bell end of the last length laid, into which he guides the spigot end of the descending length, aided by the other man, who grasps its bell end. When the bell of the descending length is from 12 to 18 inches above the blocking, and its spigot end has entered the bell end of the last length laid, the man on the derrick brake releases the latter and the length falls free. This causes it to strike the blocking with sufficient force to firmly bed the latter. The length is once more raised by the derrick to just clear the blocking, and is then pushed home with a bar by the man at its bell end. The foreman in the meantime has gotten into position to sight along the line, and if the length is in line, he gives the signal to lower; if not, he indicates the shifting required before lowering.

The length is prevented from getting out of line by the insertion of blocks and wedges between the pipe and each side of the trench, several feet back of the bell. These blocks are not removed until earth has been refilled around the pipe along four or five feet at the centre of the length. In the case of cement joints, this refilling always is done before the joint is made, but in the case of lead joints, such partial refilling need not be done. Where the trench is at all unstable, this refilling is of great importance.

While this blocking is being done, the men who removed the skids place them across the trench, in the proper position for the next length, and roll this length upon the skids in position for lowering, and then are ready to assist in moving the derrick to the new position. From this point, the sequence of operations already described is repeated.

As soon as the length is wedged into position, two caulkers start to drive in wedges on the front block, viz., the one under the spigot end of the length just laid, and raise this spigot end until it is central in the bell end of the length last laid. The joint is then yarned. (An alternative yarning method is to send in one

strand of yarn at the time the spigot is entered in the bell.) At this time, wedges may be driven on the back block, care being taken not to raise the length off this block.

In laying pipe, it often is necessary to remove shoring. This work is done by the pipe laying gang, and may require the especial attention of the foreman to prevent too many shores being out at any one time, or too great delay in replacing them, for carelessness in these matters may involve damage to both work and workmen.

Small Mains

For small mains, under the ordinary city conditions, where each job is only one or two blocks in length, the entire main gang will not exceed 18 men, and will include 2 caulkers and 4 pipe men.

After the trench has been completed, or nearly so, and any special connection to existing mains finished, the caulkers and pipe men are started on the bell holes. Each bell hole should extend from 18 inches in front of the bell to the back of the bell, and should have a clearance of 6 inches under the pipe and of 15 inches on each side. Back of the bell hole, a notch is cut in the bottom of the trench for the block, but care is taken to make the top of the block slightly above the trench surface.

While the pipe is being laid, two men are in the trench, one a caulker at the spigot end of the length to be laid, with a spirit level and a bundle of yarn strips, cut to the proper length, and the other a pipe man at the bell end, with a porter (see page 127). Three pipe men are on the bank, and one inserts a porter in the spigot end of the length as it lies alongside the trench, and lifts it. As it is raised, a pipe man slides over the spigot end a loop of rope already made and resting against the end. He holds one end of the rope and passes the other end to a pipe man on the other side of the trench. The two men take up the slack on the rope, and then the man who raised the spigot end with the porter, goes to the bell end and pushes the pipe into the trench. The men holding the rope attached to the spigot end, prevent that end from dropping all the way to the bottom. The two ends of the rope are then taken by one of the two men, and he straddles the trench, while the man in the trench at the bell end raises this end with his porter. The length is thus suspended only a few inches above the trench bottom. The spigot end is caught by the caulker in the trench, who wraps a piece of yarn around it and

enters it into the bell end of the length last laid. It is then pushed home by the man at the bell end. Now one end of the rope is dropped, and after entering the spigot end, the caulker pulls the rope from around the pipe and goes to the bell end. Here he places his level on the pipe to see whether there is the proper fall. If not, the proper level is obtained by varying the blocking, the pipe being raised by the pipe man in the trench, and the caulker inserting the block which is handed to him by the pipe man on the bank, who had held the rope.

In the meantime, the other two pipe men on the bank have gotten another length into position for lowering, with the rope under it, as described before. The second caulker is following along, driving in the yarn put in by the first caulker. When all the pipe has been laid, or it is desired to begin making joints, the foreman straddles the trench at one end of the line, and lines up the main by the aid of two pipe men who walk along in the trench, one on each side of the pipe, each with a long bar.

The procedure above described will care for mains as large as 8-inch. For 12-inch, there is needed two more pipe men and another rope to be used over a porter inserted in the bell end. The rope at the spigot end always will require two men.

There will be instances where 16-inch pipe may be laid without a derrick, and in that case it will be treated just as 12-inch, with the addition of two more men to the pipe-laying gang.

Connection Work

Closing Gaps

The procedure followed in straight pipe laying has oeen covered pretty well, but some other necessary phases of main laying are still to be described. Every new main is connected at one or both ends to existing mains, and often neither connection is made until the close of the work, and involves, therefore, the closing of a gap. With 8-inch and smaller pipe, this connection can be made by "folding in" instead of sleeving, if the trench is free enough of obstructions to permit whatever deflection from a straight line is required for the "fold." As far as possible, it should be known before laying is begun, in what way connection will be made to the existing main. If by folding, then a gap, say, 2 inches more than the laying distance of two lengths, should be left. This will make the folding a little easier, and by distributing the two inches over the three joints making up the fold, no one joint will be very far from home. In folding, the far ends

of the two lengths forming the fold are put home in the ends of the lines to be connected, and then the adjacent ends of the folding lengths raised by ropes until spigot will enter bell, when they are lowered into line, and the joints equalized, if necessary, as indicated by each of the bells concerned in the fold, being equally far from the line marked on its engaging spigot. This line shows where the bell should come if the spigot is home, and should be marked on every spigot forming part of a fold where there is over half an inch slack to be taken up per joint.

For pipe 12-inch and larger, the use of a sleeve usually is preferable to folding. Much time has been taken in attempts to fold large pipe, in order to avoid the fancied disadvantages of a sleeve, and to save one joint, and often all the time spent was lost and the sleeve resorted to after all, especially if the foreman tried to work without any slack. A sleeve will enable a spigot piece to be used, and in large work, where a stock of old spigot pieces may be on hand, the gap left should be of the right length to use up one of these pieces without further cutting. Where a pipe must be cut for the gap, its length should be at least one inch less than the distance between the face of the bell and the end of the spigot to be joined. This is especially important in very large pipe where the cut may break out a little jagged, and where an attempt to make the cut piece, just the distance between bell and spigot, is apt to result in a piece too long at various points, necessitating a tedious cutting off of these projections. Naturally, in using the cut piece, the more uneven end is put into the sleeve. Before the cut piece is lowered into the trench, the sleeve is placed over the spigot end of the gap, and on this end, and also in the end of the cut piece to go in the sleeve, a line is marked at 7 inches back from the end. Then the cut piece is lowered and put home in the bell, the sleeve is slipped forward over the gap and placed so that each face is equidistant from the marked lines. Such a sleeve joint involves an air gap of at least an inch longer than the bell depth. Unless the sleeve used is provided with internal ridges to serve as a joint backing, this gap should be covered by sheet metal, to prevent any chance of the yarn and lead, or cement, from either sleeve joint finding their way into the pipe.

In all work that involves an open pipe end where gas is being held back by bags or stoppers, if the end is to be left untouched for over five minutes, a plug of some kind should be inserted as an additional precaution against gas escape.

Cutting Pipe on Bank

The procedure in cutting pipe on the bank is as follows: The proper length is marked off from either end of the pipe at four points at least. If the measurement is made from a bell end, the necessary allowance must be made for the bell depth. The pipe then is rolled until a line has been drawn completely around it, through the marked points. Before cutting begins, it is placed on skids, one under the end farthest from the cut, and the other under the cut, and care taken to see that it stays there. No support at all should be placed under the short end. The skids should be placed as solidly, and as nearly level, as possible, in order that the pipe will not jar out of position during cutting. Each skid should be long enough to allow at least one and one-half revolutions of the pipe. For pipe 12-inch and smaller, one man holds a dog chisel (D, Figure 26, page 136), one strikes with a 14-pound sledge, or a 10-pound striking hammer (D, Figure 19), and a third rolls the pipe. For larger pipe, there are two men striking, and a man at each end of the pipe rolling it and keeping it in proper position. In every case, a continuous cut is made around the pipe, and is a comparatively light cut, not more than an eighth of an inch deep. On its completion, the cutting continues around the pipe as many times as may be necessary until separation occurs. With proper care, a clean cut always will be made. If for any reason the pipe breaks off irregularly, and the result is one or more places over 2 inches shorter than desired, another cut probably will be required, unless the irregular end can form part of a deep sleeve joint. Any projections beyond the desired line can be cut off, but comparatively light blows must be used to prevent cracking back of the line. The eyes of the workmen should be protected by goggles.

Connecting to Existing Main

At times the new main will be connected at the start to the existing system, and laying proceed without leaving any gap, gas being kept back by bagging. When a gap is left, however, the connection and any necessary alteration to the existing main need not be done at once, and as such alteration usually is harder than straight pipe laying, some foremen have a bad habit of putting it off till the end of the job. As a rule, expense will be saved by doing all the work necessary to close the gap, except the actual closure, early in the job. It already has been noted,

on page 230, what an influence the connection to the existing main has on the bottoming of the trench.

In connecting to existing mains, the Philadelphia schedule is as follows:

Schedule of Main Connections

Size of New Main	Size of Existing Main									
	30-inch	24-inch	20-inch	16-inch	12-inch	8-inch	6-inch	4-inch	3-inch	2-inch
	Hat flange	Hat flange	Hub sleeve	Insert branch	Insert branch	Insert branch	Insert branch	Insert branch	Insert branch	Insert branch
4-inch	"	"	"	"	"	"	"	"	"	"
6 "	"	"	"	"	"	"	"	"	"	"
8 "	"	"	"	"	"	"				
12 "	Insert branch	Insert branch	Insert branch	"	"					
16 "	"	"	"	"						
20 "	"	"	"							
24 "	"	"								
30 "	"									

As is seen, the idea is to use a hat flange wherever the disparity between the connecting mains is very great, and the largest so large that a hub sleeve would involve heavy cost. As the disparity and the size of the largest main decrease, hub sleeves are used, and then ordinary branches. It is not possible always to follow the schedule strictly. Occasions arise where local conditions force the use of a hat flange, or hub sleeve, because of no room to insert a branch.

Inserting Branch

The absence of the needed branch from the existing main, may be due to the opening of a street not provided for when the main was laid. What branches to provide has been considered under "Location of Branches," page 72. In mains under 12-inch, the insertion of a branch is not attended with any special difficulties, but with large mains, the work requires considerable care, chiefly in regard to the cutting of the pipe and the bagging off of gas flow. The insertion of a branch will here be described without, however, any detailed description of bagging, as this will be taken up further on in the chapter.

The location of the branch being determined, a sufficient length of the existing main is uncovered to afford room for bag holes on either side of the proposed cut, and it never pays to skimp in trench width, either. Usually there is not much leeway in the branch location, but it is not advisable to cut a pipe nearer than one foot to any bell. By cutting a little from the spigot of the branch, and sometimes by reversing the branch fitting end for end, a desired flexibility of dimensions may be obtained. When the exact location of the branch has been settled, then the two points of cutting are marked carefully on the existing main, and the pipe cleaned thoroughly at these points. The length of the place to be cut out should be about an inch longer than the overall length of the branch. In determining the points for the cuts, the effect of the bell depth upon the location of the branch should not be overlooked.

After the line of the cut has been chalked on the pipe, if the latter is smaller than 12-inch, then, by means of a diamond point chisel (A, Figure 26), a cut at least an eighth of an inch deep is made across the top semi-circumference. This cut is deepened by repeated going over with the diamond point until about half the thickness of metal is left. The whole cut is then gone over with a cold chisel (E, Figure 26), after which the chisel is placed in the cut at the top and driven into the pipe. It is then removed, and a bursting wedge (F, Figure 26) inserted and driven home until the pipe cracks completely around in the line of the cut. The same performance is repeated at the other cut, and the cold chisel is not driven into the pipe until both cuts are ready for such driving. In this way, after the pipe has cracked at the first cut, and is soaped up temporarily, nothing remains to be done at the second cut except the driving of the cold chisel and of the bursting wedge. When the section has broken clear, it is hammered out of line, or perhaps it may be necessary to break a few pieces out of it to free it. Of course, before the cold chisel has been driven in, bags have been inserted to stop the gas flow.

Where the main to be cut is 12-inch or larger, the difficulty of making a crack already started in the cut, follow around the uncut portion of the pipe increases very much with the size of the pipe, and in no class of main work is it more advisable to bear in mind the adage of "more haste, less speed," than in cutting large pipe in the trench. It will pay, in the long run, to cut just as large a proportion of the circumference (at least three-

quarters) as can be gotten at. The cut is made in the same way as just described for small pipe. The cold chisel should be driven into the pipe not only at the top, but in several other places around the cut. Two bursting wedges should be used, and great care taken to see that they keep in the plane passing through the cut. Otherwise the wedges will not exert a pressure tending to crack the pipe along the cut, but there will be great danger that they will cause cracks to run into the main on either side of the cut. If the cutting has been done properly, the main will crack slowly all around the circumference as the wedges are driven in.

Where the pipe is 24-inch and larger, it is often advisable to make three cuts, the third cut being about one foot from one of the other cuts. When only two cuts are made, and the length of the pipe cut out is considerable, it happens sometimes that even after the section is cracked around the circumference at both cuts, it remains wedged in the line of main, and requires much work to get out. The reason for this is given in the next paragraph. Under these conditions, where there is a third cut, the bursting wedges are driven into it in such a way as to cause cracks each side of the cut, and to break off portions of the pipe. After that, it is comparatively easy to remove the first section, and then the rest of the cut-out section.

In cutting a line laid with lead joints, the pressure brought to bear by the bursting wedges seems sufficient to make the pipe take up at the joints adjacent to the cut, and thus the desired separation of the edges of the cut is obtained. With cement joints the strength of the joints is too great, apparently, to be overcome, and so if the pipe being cut is under compression, or, in other words, is at a higher temperature than when the joints were made, the desired separation at the cut will not be obtained by the wedges, and in that case it is necessary to cut around the entire circumference with diamond points and cold chisels, and dispense with bursting wedges entirely.

In every case, the pipe should be supported rigidly at each cut by blocking. Otherwise, there will be great danger of cracks being caused in the pipe on either side of the cut-out section. If one of the cuts, say A, comes back of a bell and nearer than a foot to it, and the other, say B, in front of a bell, then it is advisable to force the wedges into A and sledge away the bell portion before driving the wedges into B. This program

tends to give a cleaner break at B than otherwise would be possible, but is applicable only when A is near a bell.

The process of inserting a branch after the section has been cut out, amounts to closing a sleeve gap, and has already been described. With large pipe, if a cut pipe is used to extend from any bell of the branch, the cut end should be inserted in the branch for ease of withdrawal, as compared to an end with a spigot head, in case unforeseen developments should necessitate a change in the branch. The neglect of this precaution added greatly to the task of replacing a tee with a cross in a 36-inch main.

Putting on Hub Split Sleeve

When the connection to the existing main is made by the use of a hub split sleeve, that portion of the pipe to be covered by the sleeve is cleaned thoroughly, generally with foundry brushes. Then the two pieces of the sleeve are bolted loosely around the main, to see first whether the distance between outside of main and inside of sleeve is sufficient for jointing room, and second, to mark on the main the location of the circular cut. The sleeve is then removed and the pipe diamond pointed along the marked circle, beginning at the top. The cut is then gone over with a cold chisel, going into the pipe, except for 2 inches at the top, where a lip is left to hold in place the piece being cut out. A soaped wooden plug, of proper size to fill the opening in the main, is kept on hand for use in case the piece drops out unexpectedly.

A ring of some soft material, yarn, or wire-covered rubber hose, is laid around the outside of the cut, and the sleeve placed in position on the main and pressing on the ring, which forms a more or less gas-tight joint, and also prevents any jointing material from either end of the sleeve getting into the pipe. The flanges of each half sleeve, if planed, are coated with white lead, but if rough, a layer of millboard softened in warm water, also is placed between the two flanges. All of the bolts are drawn up hand-tight and then tightened by wrench, no two bolts on the same flange being tightened in succession, but the progress being from one end of the sleeve to the other, alternating from side to side. The sleeve must be blocked in position before starting to make the joint.

In making up the joints at each end of the sleeve, if the latter is provided with internal ridges, the work is similar to any ordinary joint. If there are no ridges, care must be taken, if lead

is being used, to be sure that the yarning is so well done that lead cannot get back past the yarn into the sleeve. If it does, a mispour may result. If cement is being used, where there are no ridges, yarn is introduced from one end for about 4 inches into the lower half of the sleeve. Then cement is put in from the other end of the sleeve until the yarn is reached. As the level of the cement rises, more yarn goes in, until finally the sleeve is filled from the far end. The joint is driven from that end, and then cement introduced at the other end to fill the 4-inch space. This cement is driven, and both joints finished in the usual way.

The actual sequence of events is as follows: When the sleeve is bolted tight, a short piece of pipe, or a bend if necessary, is inserted in the hub of the sleeve. Then enough cement is put into the sleeve and the hub joint to make them gas tight. If a straight piece is in the hub outlet, a wooden plug is placed in the end of this piece. This plug is drilled to allow the passage of an iron rod, and with the latter, the disc piece is knocked into the main. The rod is then withdrawn, the hole in the plug soaped up, and the sleeve and hub joints finished. If a bend is in the hub outlet, the former has been drilled previously by a hole so placed that a rod through it will knock out the disc piece. In the bend, this hole, and in the straight piece, a specially drilled hole serves for a bag hole when more pipe is laid.

Placing Hat Flange

After cleaning the main at the desired position, the hat flange is tried for fit, it being desirable that there should be "iron to iron" contact with the pipe, especially at the bolt holes and around the edge of the opening. By covering the pipe with red lead and slightly moving the hat flange, the high points on the latter are indicated and chiselled off. When the hat flange is considered a sufficiently good fit, it is held in position, the mark made for the circular cut in the main, and the location of the tap bolt holes accurately centred by a punch provided with a bushing which just fits the bolt holes. Then the hat flange is removed, and the circular cut in the main made just as described for the hub sleeve. It is advisable to make this cut *before* the bolt holes are drilled, as otherwise there is danger of a crack extending between the cut and a hole, under the influence of the constant hammering while cutting.

A hole is drilled and tapped, and into it is bolted the "dead man", or "old man" (B, Figure 29, page 142). From this

position, adjoining bolt holes are in succession drilled and tapped out for the stud bolts, soap or clay being used to plug the holes as made, the "old man" being moved into new holes as found necessary to complete the work.

The face of the flange is covered with white lead, over which a linen gasket, previously soaked in linseed oil, is placed, and the flange screwed down first hand-tight, and then with a wrench, tightening in diagonal succession. Around each bolt is a piece of lamp wick. The material used between flange and pipe will vary with the individual using it. Millboard, canvas, lead, cement, are all available. In general, the more nearly iron to iron the joint, the better.

The details of inserting an outlet into the hub of the hat flange and of removing the disc from the main are exactly similar to those already described for the hub sleeve.

In placing hat flanges, a number of tools are needed which are seldom, if ever, used for any other kind of main work, and for this reason, and also to ensure on hat flange work the presence of the necessary equipment, it is advisable to have this equipment contained in a special box, which is delivered on the work when required. The box is 8½ by 8½ inches by 2 feet 7 inches long, and contains the following equipment:

2 6-inch Cold Chisels,
2 Twist Drills, $\frac{11}{16}$ and $\frac{21}{32}$-inch, with taper shanks,
1 12-inch Flat Bastard File,
2 Syphon Gauges,
1 1½-lb. Ball Pein Machinist's Hammer,
1 "Old Man" and attachments,
2 Diamond Points,
1 Center Punch, ordinary,
1 " " with bushing for centering,
1 Boiler Ratchet, with 11-inch handle,
3 Pipe Reamers, ⅜, ½ and ¾-inch,
2 ¾-inch Bolt Taps, with square shanks,
1 Hexagon Cap Screw Wrench, single head.

Joints

Yarning

For pipe no larger than 16-inch, one caulker only is needed to yarn a joint. The yarn is cut from 1½ to 2 inches longer than the outside circumference of the pipe (and it is not good practice to

use at any time, any length of yarn shorter than the outside circumference), as determined by taking one end of the yarn from the bale and passing it around the pipe. After a number of pieces have been measured in this way and cut from the bale, a sufficient number of strands are taken from these pieces, to make, when twisted together, a rope large enough to fill solidly, when compressed by the yarning iron (Figure 39, page 158), the radial space between spigot and bell. The proper number of strands for the size pipe being laid, having been determined and twisted together, one end of the rope so formed is tacked in the right-hand side of the joint by the yarning iron and pushed at least halfway in. The balance of the rope is then stretched around the pipe, being kept carefully in its twisted state, and driven back halfway. This method of working brings the caulker around to the right-hand side where the yarn was entered first, and he continues around a second time, driving the yarn home this time. In thus making two circuits of the pipe in yarning, the yarn remains at all times more nearly in a plane perpendicular to the axis of the pipe, and there is little danger of disturbing the lap.

Where cement joints are used, only enough depth of yarn is needed to support the weight of the spigot end and keep it central in the bell without any chance of sagging while the cement is setting. Any more than this amount is occupying, uselessly, space needed for requisite depth of cement. It is very important that the yarn be driven very solidly. Also for cement joints, the front yarn is cut and prepared for the drivers, and laid across the pipe against the face of each bell when back yarn is driven, or at any time after the pipe is lined up. This method saves the drivers from carrying yarn from joint to joint, it renders uniform the number of strands used, not leaving this to the driver's discretion, and it prevents dirt getting into the joint.

Where lead joints are used, the depth of yarn is determined by the depth of the bell, and of the lead required. Each layer needed is put in as was the first, but a new starting point is taken, so that the lap of one layer does not come above that of a preceding layer. The most satisfactory way to ensure the proper depth of yarn is to measure back from the driving point on each yarning iron (Figure 37, page 155), the depth of lead desired, and stop yarning when the point is touching the yarn and the mark is just hidden.

Mains 12-inch and larger, being blocked under the spigot end as well as the bell end, do not depend on the yarn to hold the spigot central in the bell, and, therefore, under these conditions, for cement joints only enough yarn is needed to prevent the cement getting inside the pipe.

For mains over 16-inch, two men are needed to yarn a joint. The yarn is inserted and driven just as described for the small mains, except that each man works alternately on his half of the joint until the yarn is completely back. Then both men drive at the same time until the yarn is compressed properly.

Jute yarn of a middling quality should be used, with fibres long enough to form strands that will twist properly. In this yarn a certain amount of oil will be present, but careful buying will eliminate any bales with an excessive amount. Tarred yarn should be avoided, as the tar squeezes out under driving and deposits a film on the iron surfaces, which is detrimental to the tightness of lead or cement. For cement joints, some men use yarn soaked in grout, but the general preference is for dry yarn, both at the back of the bell and for driving, as it is considered advantageous to soak up some of the water squeezed out of the cement by driving.

The exact weight of yarn required per joint will vary not only with the depth of yarn used, but also with the tightness of the driving. The schedules below represent New York practice with cast lead joints, and Philadelphia practice with cement joints:

	New York City		Philadelphia	
Size of Main	Depth of Yarn (Inches)	Weight of Yarn (Ounces)	Depth of Back Yarn (Inches)	Weight of All Yarn (Ounces)
4-inch	..	..	$\frac{3}{4}$	6.0
6 "	2	2.0	$\frac{3}{4}$	7.5
8 "	2	2.5	$\frac{3}{4}$	9.0
10 "	2	3.0	..	..
12 "	2	3.5	$\frac{3}{4}$	12.0
16 "	$1\frac{3}{4}$	4.0	$\frac{3}{4}$	17.0
20 "	$1\frac{1}{2}$	4.5	$\frac{3}{4}$	30.0 (5" bells)
24 "	2	5.0	..	..
30 "	2	6.5	$\frac{3}{4}$	50.0 (7" bells)
36 "	2	7.0	..	..
48 "	$2\frac{1}{2}$	8.0	..	..

Lead Joints

A discussion of the relative advantages of a lead, as compared with a cement, joint will be given when describing the latter joint.

Although depths of bells have been more or less standardized, there is much variation in the depths of lead used by different companies for the same sizes of pipe. Below is given the Philadelphia schedule for sizes to 30-inch inclusive, and the New York schedule for 36- and 48-inch:

Size of Main	4″	6″	8″	12″	16″	20″	24″	30″	36″	48″
Depth of Lead	$1\frac{1}{2}$″	$1\frac{3}{4}$″	2″	$2\frac{1}{4}$″	$2\frac{1}{2}$″	$2\frac{1}{2}$″	$2\frac{3}{4}$″	3″	$3\frac{1}{3}$″	$3\frac{1}{2}$″
Approximate Weight	6 lbs.	9 lbs.	12 lbs.	22 lbs.	36 lbs.	50 lbs.	62 lbs.	75 lbs.	124 lbs.	165 lbs.

In considering any depths of lead, it should be remembered that the compression due to the most vigorous caulking does not extend deeper than about $\frac{7}{8}$-inch below the surface of the joint.

While the pipe is being laid and yarned, one pipe man has been assigned the job of building a fire under the lead pot (A, Figure 33, page 149), and having the lead hot when needed. He also brings to the proper consistency, the red clay used for the pouring gate. The first step taken to pour a joint is when a pipe man puts on the rubber band (A, Figure 36, page 153), being careful to drive it back closely against the face of the bell while tightening it. At the top, a pouring gate is made by the use of red clay, which also is smeared around the band where it touches the bell. The larger the pipe, the more important become all steps taken to ensure the tightness of the band and prevent any leakage of lead.

For mains as large as 16-inch, the man who puts on the band also pours the joint. He receives the ladle (A, Figure 35, page 152) or, for 16-inch, the pot (C, Figure 35), from the man in charge of the lead pot. For 20-inch and larger, two men are required to carry the pouring pot from the lead furnace (B, Figure 33) to the trench. One of these men lowers the pot with a rope and hook (B, Figure 35) and holds the weight, while the man who put on the band takes a hook (D, Figure 35) and pours the pot. The other man goes back to the lead pot, fills a hand ladle, and stands with it resting on the pot, ready to bring it quickly if needed.

On 30-inch work, two men are assigned to place the band, and one of these men stands alongside the pipe while the joint is being poured, with clay in hand, ready to stop any leakage of lead. Where it is necessary to use more than one ladle, or pot,

for a joint, the interval between pourings should be as short as possible. If for any reason a joint should not be fully run, and the lack occurs in the upper half, the surface of the lacking portion may be roughened, a gate made around it, and very hot lead poured. If the lower half of the joint is lacking, it probably will be better to cut out the joint and repour.

When the joint has been poured, a short interval is allowed for cooling, and then the band is removed and placed on the next bell. The joint is now ready for caulking, and for mains up to and including 16-inch, there is but one caulker to a joint. A caulker should drive five 6-inch joints each hour, four 8-inch, three 10-inch, two and one-half 12-inch, or two 16-inch, the lineal inches of lead as measured on the circumference being about the same in each case. For 20-inch and larger pipe, two men are required to a joint, and the awkward position in which some of their work must be done does not allow the results obtained on the small pipe, so that for two men two 20-inch joints, one and one-half 24-inch or one 30-inch will be about the hourly result.

In caulking, the tools shown in Figure 37 are used. The joint is first chiseled all around between the lead and the spigot, no scale, or fillet of lead, being left against the iron. When this chiseling has been done, except at the gate, the latter should be cut off, but far enough from the face of the bell to allow sufficient lead for caulking. After chiseling at the gate, the caulker begins with his smallest tool and encircles the joint. He then repeats this performance with the next largest tool, and so on until he has used the largest tool possible for the size of pipe being laid. When this is done, the joint is completely faced, the lead will be driven about flush with the face of the bell, and the joint could in ordinary practice be considered finished. Some experiments made in Philadelphia in 1901 showed, however, so much greater resistance to strains brought to bear on joints by deflection and tension when these joints had been caulked twice, than when caulked only once in the usual way, that it is the Philadelphia practice to caulk all joints twice. In other words, after the joint has been caulked as just described, each caulking tool is again used. Of course, this almost doubles the cost of caulking, which, however, due to the almost exclusive use of cement joints, is not a large item in Philadelphia.

Each caulker should be provided with a steel stamp, containing a distinctive number or letter, and with this should stamp each joint made by him. Such identification of work has a

moral effect very favorable to good results, as it enables the responsibility for a leaking joint to be placed against the original caulker.

The number of caulkers spoken of in this and preceding chapters as forming part of main laying gangs, has been based on cement joints, and more will be required where lead joints are made, due to the longer time required for caulking lead, as compared with stuffing cement.

Cement Joints

General

The substitution of cement for lead as a jointing material for bell and spigot cast iron pipe is almost entirely a development of this century, but in that time many thousands of cement joints have been made, with such favorable results on the score of tightness and of economy in labor and material, as compared with lead, that the gas engineer using lead for mains under 16-inch has the burden of proof against him. In Philadelphia, in the last 14 years, 460 miles of cement joints in these sizes, have been laid, and the number of leaking joints is about one in every two miles.

For some time after the adoption of cement for most of the small main work in Philadelphia, lead was still used for small mains laid in the congested districts, and for all large mains. It was thought that as the tendency of 8-inch or smaller pipe laid with cement, was to break across the pipe, rather than at the joint when under a stress, especially one due to contraction, it was safer to use lead in all locations where other structures, especially conduits, abounded, as it seemed preferable under those conditions to have a number of small leaks in lead joints, than one leak which might quickly fill conduits and manholes with an explosive mixture. Cement joints have caused so few broken mains, however, that the tendency now is to use cement joints in all small mains, except possibly where the cover is very great, or where the renewal of a joint would prove very troublesome. One advantage of a lead joint is, of course, that if it leaks, simple re-caulking usually will effect a cure, while the cement joint must be cut out entirely, and the conditions under which the joint must be re-made are not as favorable for a tight joint as if the pipe was being laid for the first time. Dirt is apt to get into the joint, and perfect adhesion may not be obtained with particles of the old cement left clinging to the pipe. It is

also quite evident that if the space surrounding the defective joint is rather confined, the man cutting out the joint may suffer from the effects of gas. For all the above reasons, therefore, lead joints are preferable in all special locations where future joint trouble is expected. Among these would be places where a good foundation may not be secured, and, therefore, more or less settlement is anticipated.

The above is based on the idea that a leaking cement joint is to be replaced by a second cement joint. With the advent of lead wool, however, it is possible to cut out but 1½ inches of cement and make a tight joint by filling this space with lead wool. This new practice very much lessens the objections to the use of cement joints under the conditions just considered.

To return to the history of Philadelphia's experience with cement joints. At first it was not believed that cement joints could be made successfully for pipe 20-inch and larger. When this problem apparently was solved, as will be described later on, and the practice of using cement joints on large mains was adopted, it was still thought necessary to put in a lead joint at intervals to provide for expansion and contraction. It was believed that the joint might prove stronger than the pipe, as is generally true for pipe 8-inch and smaller, and hence, under severe contraction, a broken main might result. Naturally, a broken 30-inch main was not to be desired. Therefore, in laying a line of 30-inch and of 20-inch in 1902, lead was used for every eighth joint. A comparison of the distance apart of two marked points on either side of a lead joint in the 30-inch line, as between August and January, showed that the total movement could be accounted for by the contraction in only 24 feet of pipe. It is quite probable that the grip of the frozen ground against the pipe is much stronger than any stress due to temperature. In any event, as there were no cases of broken 30-inch or 20-inch mains, but only a few leaky cement joints, two facts were considered proven: first, that an expansion joint was of no use, second, that in a large main, the joint was the weakest point. This last conclusion seemed to remove the final objection to using cement joints on large pipe, and until 1914 cement joints were used generally on all main work except some 36-inch and 48-inch lines. In that year, however, it was decided that in view of the large mileage of big pipe already under ground with cement joints, together with the tendency of these joints to develop leaks after being tight for a long time, it would be more

conservative to abandon cement for joints 16-inch and larger, at least for a few years, until it was found out whether the gradually increasing number of large joint leaks would continue until all the cement joints had been replaced. At the end of 1915, the record showed a total of 1587 leaks in 31 miles of 16-, 20-, and 30-inch pipe, and this still left a margin of saving as compared with the first use of lead wool or even cast lead.

Material

Undoubtedly, Portland cement has been used almost exclusively for joint work, even in the early days when natural cement was so much cheaper. The material cost is, however, so small that few people felt justified in running the expensive risk of leaking joints through the use of natural cement, generally comparing unfavorably with Portland in fineness and uniformity of composition. In Philadelphia, when starting cement joint work in 1899, the Dyckerhoff brand was used and proved generally satisfactory, except that at times there were complaints of lack of fineness. However, in 1903, American Portland cements began to challenge attention, and it was deemed advisable to test various brands to see whether one acceptable for cement work could not be found and in this way not only save money, but also avoid certain inconveniences inevitable in buying an imported article. As a result of these tests, American brands have been used since 1903.

Each brand was tested:

First. For solidity under driving. This test consisted in noting whether the cement seemed to rock, *i. e.*, act more or less like quicksand when being driven. In driving a joint, it is quite desirable that the cement does not rock, but stays where put, so that in driving cement home at one part of the joint there is no lateral displacement, resulting in the cement rising up at other parts of the joint.

Second. For activity. A very quick setting cement would be objectionable, especially for large mains where the joints take some time to make.

Third. For soundness. The soundness was tested in several ways. Freedom from checking or cracking was determined by a standard pat test. Expansion was judged by pouring grout into some bottles, and ramming stiff cement into other bottles, and noting which bottles broke after setting. Where expansion is not due to impurities, it is an advantage for joint makers. Into some of the bottles, red ink was poured on top of the

cement. If any contraction occurred, the ink would find its way between the cement and the glass.

Fourth. For fineness. This is a standard test and was made with a No. 80 sieve.

Fifth. For adhesion. In this test a split sleeve was clamped around a pipe, and by using grease on half of the pipe, a joint was obtained between the pipe and one piece of the sleeve only. Weights were suspended from this piece until it broke away from the pipe. The strength of a cement joint under ordinary conditions is measured by the adhesion of the cement to the iron under a strain acting parallel to the axis of the pipe.

Making

The pipe having been yarned, and well secured from any possible movement by blocking it beneath and by refilled earth for three or four feet along the middle of each length, is now ready for the joint making process. On small mains the joint gang consists of 1 mixer, 1 passer, 1 packer and 2 drivers. The mixer has an iron wheelbarrow (Figure 54, page 179), a large pan, or a cement mixing board (B, Figure 38, page 156), measures for cement and water, and a small short-handled hoe (C, Figure 38). The passer has a trowel (B, Figure 36) and a pan, or a mixing board. The passer and packer wear rubber gloves, (D, Figure 36). The drivers have a caulking hammer and a cement caulking tool (Figure 39).

The surface of the bell and of the spigot included in the joint have been very carefully cleaned before the pipe is laid. For this purpose a wire brush, and perhaps gasoline, have been used at least a day before joint making, in order to give the gasoline time to evaporate.

The mixer measures out a definite amount of cement and water, and mixes it into a thoroughly homogeneous mass. This mixing should be done in the shade if possible. There always will be more or less difference of opinion as to the exact quantity of water to use, some men preferring wetter cement than others, but in Philadelphia the proportion recommended is 3 of cement to 1 of water by volume. This will make a mixture which will appear crumbly in the pan, and will just retain the impression of the fingers when squeezed in the hand. No more should be mixed in any one batch than can be used in the time before setting begins. This time will depend on the quickness in setting of the cement being used, as shown by the activity

tests. Ordinarily, 20 minutes is the maximum time that should lapse from the mixing of water with the cement to the final work on any joint on which that particular batch of cement was used. The mixing pan, or board, should be kept scraped clean of all old cement. In practice, of course, it is hard to ensure that the mixer will always follow these rules relating to small and fresh batches, but the larger the pipe, the more certain it is that carelessness in these matters will mean leaky joints.

A batch being ready, the passer cuts from it, with his trowel, a wedge-shaped piece and hands this to the packer, who is astride the joint. The packer takes the cement from the trowel in his gloved hands, and starts to pack the joint from the bottom. He works up both sides together, finishing at the top, using the sides of his hands and fingers to push in the cement. He considers the joint to be fully packed when, on pushing his fingers on the lower half of the joint, the cement pushes out beyond the face of the bell at some point along the upper half. When this is the case, he starts from the bottom and coming up simultaneously on each side, wipes away with the finger tips of each hand, any cement on the spigot outside of the bell and on the face of the bell itself. At this point in the process the cement occupies the whole space A–D, Figure 77.

The driver now begins by taking up the yarn strands, already prepared for him, as described on page 244, and lying across the pipe. These he twists if necessary and tucks one end in on the left-hand side of the joint near the top and carries the yarn around the face of the joint, holding the free end at the top of the bell to keep it taut. He then starts with a yarning iron (Figure 37) to push the yarn in past the face of the bell, working down along the left-hand side and up to the right-hand side to the starting point at the top. The yarn has then entered the bell all the way round, and the excess cement is scraped off by the caulking tool and drops to the bottom of the trench. Beginning at the first starting point, the driver now goes around the joint in the same direction as before, caulking the yarn until it feels solid under the caulking tool. The proper amount of driving to be done to a joint may not be described, but can be learned by experience only. It is quite possible to drive the yarn too hard. When the yarn begins to show moisture, it is a usual indication that enough driving has been done. The driving yarn then occupies the space B–C, and the cement the space C–D, Figure 77.

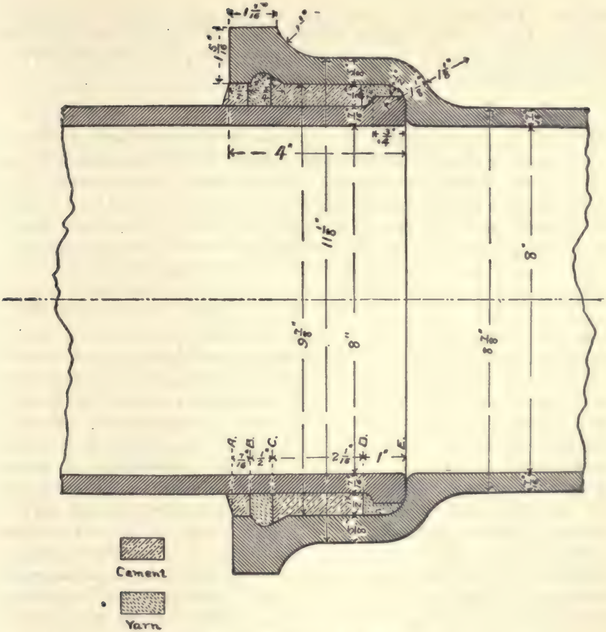


Figure 77. — Cement Joint, page 252.

After packing all the joints laid out for him, the packer starts at the beginning of the line, and fills the space A—B, Figure 77, with cement, leaving a surface flush with the face of the bell as shown. This last fillet of cement serves merely to protect the driving yarn from the soil, not being gas tight itself. Rather wet cement of doughlike consistency is used, 45 pounds being mixed at one time on 6-inch work, enough to make 12 joints.

A gang of five experienced men following the procedure above described, can make thirty 6-inch joints in an hour, or twenty-four 8-inch joints, or twelve 12-inch joints. For mains 16-inch and larger, the gang is composed of 1 mixer, 1 passer, 2 packers and 4

drivers. The method of working is the same as for the small mains. Ten 16-inch, eight 20-inch, six 24-inch or five 30-inch joints represent what can be done per hour by these eight men when experienced.

Temperature Precautions

While the use of cement joints on small pipe dates back for many years, it is believed that only since 1902 have cement joints on large pipe been successfully made on an extensive scale. At that time, the Philadelphia Gas Works determined to use cement on its large mains if possible, and after a few weeks of failure, involving the cutting and re-making of several scores of 20-inch joints, it was discovered that if the temperature of the main was kept nearly constant from the time the joint was stuffed until it had set, tight joints would be the rule and not the exception, even on 30-inch pipe. In order to give the finished joint, the least possible strain due to temperature changes, it is advisable to have the temperature of the pipe as close as possible to mean underground conditions. This perhaps is attainable only when main laying occurs during the spring or fall months. Therefore, it is the Philadelphia practice to give preference to these months for large main laying, and this usually is quite feasible because the need for such mains is seldom so imperative that a delay from winter till spring, or summer till fall, is not possible. Small mains have to be laid, of course, at all seasons of the year, but, fortunately, a given range of temperature during joint making and setting does not seem to have the same harmful effect on a small as on a large pipe. Indeed some, people do not believe it is necessary to take any temperature precautions when laying pipe 8-inch and smaller, but such a course will often involve a risk out of proportion to the slight saving involved.

What are the temperature precautions to be taken? To begin with, if the pipe has been exposed to the rays of a hot sun long enough to become warm, joint making should not start until the iron has had a chance to cool to the air temperature. Ordinarily, pipe can be laid one day and joints made the next, in which case there is plenty of chance for the necessary cooling. If, however, joint making must occur the same day, it may be necessary to use water on both bell and spigot ends just before laying, to bring down the temperature quickly. Neither bell nor spigot should be left wet, for such a condition would add undesirable moisture to the cement. It also may be necessary, when

the pipe, after being laid, is exposed to a hot sun before joint making, and there will be no chance of its cooling through atmospheric changes, to sprinkle it with water applied at frequent intervals by a sprinkling can, or to adopt any of the precautions described later on as being taken after the joint is made.

The most acceptable time for joint making on a sunny day is in the late afternoon or early morning. The pipe being at about the existing air temperature, and joints having been made at either of these times, the problem is to prevent a range over 10° in temperature for the time intervening between joint making and testing. What this time should be, will be discussed later. If the time is 12 hours, making in the afternoon is preferable, as the night range of air temperature usually is less than the day range in the sun.

The earth that has been refilled midway around each length, not only helps to keep the pipe securely in position, but protects the covered portion from temperature changes, so that only about four feet each way from the joint remains to be protected. There are several ways of doing this. One method very effective, but comparatively expensive and hardly necessary, except perhaps for 30-inch pipe, is to place a few inches above the pipe a platform of loose boards, itself covered by 6 inches of earth. The dead air space thus formed acts as an efficient insulator, and in very hot weather it may be found advisable to build the platform after the pipe is laid, removing it for joint making and replacing while the joint is setting. Following this procedure on a line of 30-inch laid in May, air temperatures *under* the platform varied in 48 hours from 56 to 61 degrees only, while the corresponding range of the outside air was from 53 to 74 degrees. This record is typical of what is accomplished by temperature precautions.

Another method of maintaining temperatures constant, which has proven quite acceptable under ordinary conditions, especially with pipe 20-inch and smaller, is to cover the exposed portion of the pipe with coarse bagging, kept wet by sprinkling. If the days are hot and the nights cold, it is a wise precaution to let the bags dry out toward dark, otherwise evaporation might bring about a pipe temperature lower than normal. Still a third method, applicable if the trench is through a smooth roadway surface, and for pipe not larger than 20-inch, is to stretch cheesecloth across the trench, and by keeping this cloth wet, protect the trench from the sun's heat.

On cloudy days, in spring or fall, often no precaution at all is necessary, and even sunny days at these seasons involve less air range between night and sun, than is true in summer. Severe winter conditions do not have to be considered, because in such weather no main laying is done,—only repair work. In Philadelphia, cement joints are ordinarily used on this work, and resulting leaks, if any, have been few. The joints would be made as soon as the pipe was uncovered, and refilled right after making, so that ordinarily on winter work, the temperature of ground, pipe and air would not vary far from 30° during the whole period from making to setting. In laying new pipe, it does not seem advisable to use cement joints when the air temperature falls much below 30° *

Lead Wool Joints

Many slight modifications of the bell and spigot joints have been proposed from time to time, involving a change in the bell and spigot design, but never have met with any acceptance. In the last seven years, however, "lead wool," a special preparation of lead in a fibrous or shredded form, has been used extensively on mains 30-inch and larger. Especially notable is its use in New York city on 48-inch pipe. The fibres are put into the joint in the same way as yarn, each layer being caulked. As a result, the labor costs with hand caulking (Figure 40, page 159) are, on large pipe, from three to four times as great as for cast lead. The material costs about twice as much per pound, but as less is used, the cost per joint is one and one-half times as much as cast lead. On long jobs of large mains, the use of pneumatic caulking tools (Figure 41, page 160) has improved the work and lessened the cost, and an experiment is being made with a caulking machine which will still further reduce the labor cost. However, the total joint cost still will exceed cast lead, and be so far above cement that, even though lead wool has a negligible leak record, yet for pipe 12-inch or smaller, the facts favor cement. On pipe 16- to 30-inch, cement shows more

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* Note. The above was written previous to ceasing the use of cement joints on large mains. It is still of value as throwing light on different experiences with large cement joints. Were Philadelphia to make more of these joints, the attempt would be to do the work in weather as cold as possible without adding unduly to excavation expense. Pipe so laid would almost always thereafter be in compression, and with each length iron to iron, this would involve little, or no, shearing stress being brought upon the contact between cement and iron.

leaks than cast lead, and time alone will prove whether the leaks which finally may develop in cement joints in these sizes, will outweigh the great saving in first cost. Above 30-inch, the choice lies between cast lead and lead wool. On isolated work, such as leak repairs, where size of pipe or temperature conditions preclude cement, lead wool generally will prove more convenient and, through saving in time, more economical than cast lead.

A fuller treatment of lead wool joints is impossible, both for lack of space and of personal experience. The files of the gas journals for the last seven years contain all that has been written on the subject.

Testing Joints

The ordinary small main, laid for low-pressure distribution, needs no test for tightness prior to refilling, save a test with soap suds under gas pressure. The necessity for any test has a tendency to delay main work and increase expense, and this is especially true where the test is made by pumping air into the main. Experience has shown that the test with gas is sufficient under the conditions described. The suds are applied with an ordinary shaving or other suitable brush, over the face of the joint and the adjacent spigot and bell, and any leak in the joint will be indicated by the presence of soap bubbles. There will be times when it is advisable to refill as soon as the joint is made, and to omit any testing whatever, as, for instance, where the trench cannot be kept open for any length of time, or when cement joints are used and temperature conditions are hard to maintain. In New York city the success with lead wool joints has been so great that no test is made.

When the main is being laid by contract, or when it is larger than 12-inch, it is good practice to make a test under air pressure of 3 to 5 pounds. Observations of a pressure gauge in connection with a soap-suds test of all joints, will indicate the degree of tightness obtained. If possible, the test should be made at a time when the range of air temperature is small, for in a large main there might be a stationary or slightly rising pressure, even when there are a few large leaks. Of course, the possibility of this occurrence is increased greatly if the line under pressure is quite long, as is often the case where each successive section laid is joined to the preceding sections and air pressure applied to the whole line. Where each section is tested alone, and the length of line under pressure does not exceed one thousand feet, the

gauge is more independent of temperature, but at the same time temperatures must always be borne in mind. It is possible with falling temperatures to have a falling gauge on a perfectly tight line.

When any fall in pressure cannot be accounted for by temperature conditions, and yet every joint shows tight, a search should be made for a cracked pipe. It is a very foolish act to pass a line, especially of large pipe, on a falling pressure, until every inch of main has been carefully examined.

For any volume up to 2000 feet of 30-inch pipe, the air pump, (Figure 25, page 135) is sufficiently large. For a larger volume, a motor-driven pump might be used to advantage. Outfits are obtainable in which motor and pump are mounted on a wagon frame, and may be drawn easily from place to place.

Below follows a method used in Philadelphia for an air test. The test is usually made as near 7:00 A. M. as possible. The night before, all openings in the main are plugged up, the air pump is attached to the main, and the mercury gauge is examined and made ready for attachment. In attaching the air pump, a $1\frac{1}{4}$-inch hole is tapped either on the main, or preferably, in the closing plug or cap. Sufficient $1\frac{1}{4}$-inch pipe, provided with suitable fittings to allow a $\frac{3}{8}$-inch connection with the gauge, is used to place the gauge in a convenient point for observation. Armored hose connects the $1\frac{1}{4}$-inch pipe to the pump.

Arrangements are made to commence pumping at such an hour in the morning that the required pressure will be reached at 7:00 A. M. With the pump shown in Figure 25, for a pressure of 3 pounds in 500 feet of 30-inch, four men would be needed for two hours. The test is made by two men with pound brushes and a bucket of Ivory soap suds. A foreman supervises the work and marks any leaks as found. When the test is completed, the pressure should be relieved through the standpipe, or in any other way, before removing the plug or cap at the end of the section under pressure, as, if not relieved, there is danger of injury to the workmen.

Precautions Against Settlement

Once a pipe is laid and covered up in a tight condition, the only reasons to cause breaks or leaky joints, are some agencies, usually human, acting during subsequent exposure of the pipe, stresses due to street traffic and to temperature, and settlement of the pipe itself. The first danger must be guarded against by

efficient linewalking, and will be described hereafter. The second and third are affected by the depth of the pipe and have already been discussed on page 74, but the fourth, to which is due many leaky joints in all sizes and many breaks in small pipe, will be considered now.

Supposing, as generally is true, that the trench is in firm ground, the theory used to be that the pipe should be laid on this firm trench bottom, proper excavation being made for each bell. This theory worked all right in practice where obstructions were few, and, therefore, no occasion arose to decrease the expected cover of the pipe after the trench was bottomed; and, more important still, where the gang was small in number and contained one or more laborers skillful in making a bottom that lay in one plane, and was not formed of a series of small planes. The above conditions never were obtainable in towns of any size, and usually the result of laying directly on the earth was a line supported at a series of points along each length, and resting occasionally on refilled earth where the original trench depth was too great. Trouble has resulted frequently from such conditions, and, of course, more often with large pipe with resulting heavy repair cost.

A little reflection will show that without any earth compression, the support of a length lying on the earth is a line about 11 feet long. If, as usually would be done, the pipe was allowed to drop on its bed several times, then *assuming* it always fell in the same place, there would be a concave bed probably several inches wide. Actually, however, it would be impossible to get any greater bed than one dropping would accomplish, and if such dropping did not leave the pipe in a straight line with the pipe already laid, a crook must be left in the line, or the bed disturbed.

The use of blocking obviates the difficulties above mentioned. The trench need not be bottomed carefully except where the blocking rests. In setting the block, a paving rammer should be used to ensure a firm bearing for the block over its whole area. Another good way of bedding the block is to raise the bell end of the pipe about two feet, and then allow it to fall free on the block. The pipe can now be freely moved sidewise on the block, or up and down by inserting distance pieces and wedges, with the certainty that its stability is not being affected. The use of wedges and of the distance pieces of 1-inch board, enables an exact alignment as to height, something impossible to obtain when laying on the trench bottom.

In deciding on the sizes of blocking to be used for various sized mains, there is ample opportunity for the use of individual judgment. Below is the schedule used in Philadelphia:

SCHEDULE OF BLOCKING

Size of Mains	Size of Blocking			Size of Distance Pieces			Size of Wedges		
	Thickness	Width	Length	Thickness	Width	Length	Thickness	Width	Length
3 in. - 8 in.	3 in.	12 in.	12 in.	1 in.	12 in.	12 in.	$1\frac{1}{2}$ in.	4 in.	6 in.
10 " -12 "	3 "	12 "	18 "	1 "	12 "	12 "	2 "	5 "	8 "
16 " -20 "	3 "	12 "	24 "	1 "	12 "	24 "	3 "	5 "	12 "
24 " -30 "	4 "	12 "	30 "	1 "	12 "	24 "	3 "	5 "	12 "

The blocking must be used always of full width and placed upon undisturbed earth. For mains over 16-inch, two blocks are laid side by side at each blocking point, making the width of four blocks for each length.

This schedule may be considered by some as being too liberal, but it was designed with the knowledge that a few leaking joints under asphalt would pay for many feet of lumber. Two-inch blocks undoubtedly could be used for small pipe, but 3-inch will last longer, and the extra thickness may be needed some day to prevent settlement where a block has been bedded improperly. The blocks have been made short and wide, rather than long and narrow, because the more nearly square the block is, the more apt it is to bear on its whole surface. A block which is almost as long as the trench is wide, will require great vigilance on the foreman's part to prevent many such blocks being set, having a bearing at each end only.

The surface area of the blocking as given for each size main, causes a pressure per square inch of such surface, which is the bearing surface of the blocking in the trench, varying from 32 pounds in the case of 8-inch, to 10 pounds for the 24-inch, the weight taken being that of the pipe itself and a parallelepipedon of earth, 3 feet high, 12 feet long, and of width equal to the outside diameter of the pipe. For pipe over 8-inch in size, there are two blocking places in each length, and this enables a positive support to the spigot end, which is of great advantage in making cement joints, as it enables less yarn and more cement to be used, and prevents any settling of the spigot with a consequent leak. Where more blocking area is needed than will be given by two blocks to a length, four are used,—two at each

blocking place. In this way, 3 by 12-inch lumber can be used for all blocking, the only difference between the various blocks being in their length, and these latter have been so arranged that some of the larger blocks may be cut to form two smaller blocks.

Only one objection to the use of blocking is worth noting, and that is the space left between the main and the trench bottom. The question of refilling this space will be considered in the next chapter. As already stated, a little care in insetting the blocking in the trench bottom will reduce the space to rather less than 1 inch in height, and this is important, especially with large mains.

Blocking will care for the ordinary conditions of main laying. Where the soil is of uncertain stability, or the weight exceptional, as with some special castings, especial methods must be used. Short piles may be driven into the trench bottom at each side and the blocking rest on them. Concrete or brick piers may be built. Such piers are often advisable under specials, particularly bends used where the main changes in cover, and a big pile of blocking would otherwise be required. In every case, however, the pipe itself should rest on wood and not on the pier direct.

Bagging

Necessity for Bagging

No matter how small the pipe, no connection should be made to a main either by a cut-out or by removing a plug or cap, without first stopping off the flow of gas. There are many workmen, and some foremen, who object to this precaution in the case of 2-, 3- or even 4-inch mains, and who, if left to their own devices, often would "jump in" a connection without stopping off the gas flow. Such a practice, however, should not be tolerated, as it involves too much risk to the workmen, and also to the maintenance of gas supply on the main concerned.

In the old days of small mains, animal bladders served fairly well, and there was nothing better until the advent of rubber bags (E, Figure 24, page 132), which, in turn, have been supplanted largely by stoppers (A, Figure 24) within the last decade.

Of course, the larger the main, the more dangerous would be the result of unrestricted flow, and hence the more careful provisions necessary for stopping off this flow. One bag, or stopper, should be used to prevent gas flow in mains 8-inch and smaller, and two bags, or two stoppers, or one bag and one stopper, for larger mains. The latter combination is to be preferred.

especially in the very large mains, where the stopper is not apt to fit close enough to prevent a leak sufficiently large to bother the workmen. Each bag and stopper should be in a separate hole for pipe 12-inch and larger. When two holes are required on each side of the opening, their distance apart should be, for bag and stopper, at least one and one-half times the diameter of the main, and for two stoppers, twice the diameter. Holes in pipe 16-inch and larger should be located preferably in separate excavations to the one in which the work is being done. The stopper is placed furthest from the opening; in other words, toward the gas flow, and takes up the pressure, so that the bag simply prevents what little gas may be going past the stopper, from getting into the portion of main being connected. This is on the assumption that a steel "bleeder" pipe, varying in size from 1 to 2 inches, is inserted into the tap hole for the bag, and that through this pipe there escapes into the air, well above the top of the trench, any gas leaking past the stopper. There often may be cases when a bleeder pipe is not necessary. If so, of course, the bag stands the full pressure difference, but in case the bag should break, the first stopper is the safeguard against any great gas flow.

The above venting precautions will suffice for ordinary cases of distribution mains. When working on pumping mains, however, more elaborate arrangements are advisable. Pumping mains are those which convey gas from a manufacturing station to a distributing holder or a district governor. The occasion for bagging work on these mains often arises from the necessity, usually due to city work, of re-routing a certain section of the main. Pipe having been laid in the new location to within sleeving distance of each junction with the existing main, the next step is to cut into the existing main and join it to the new portion. Besides putting the pumping main out of use while this work is in progress, it usually is possible to shut one or more valves at each end. If each valve is tight, there will be no pressure against the stoppers after the valves have been shut a sufficient time to allow the escape of the excess gas through the bleeder pipes. In practice, however, large main valves are seldom absolutely tight, and so it usually will be found that enough gas will leak past the valve to maintain some pressure against the stoppers, notwithstanding the escape through the bleeder pipes. In order to minimize this leakage, every valve should be shut whose closing will interpose another obstacle to

the passage of the gas into the main being bagged off, but will not affect other lines needed for use.

The possible existence of valve leakage, and, therefore, of higher than distribution pressures, makes advisable larger and more numerous vents for the leaking gas than are needed on distribution mains. These vents into which the bleeder pipes are screwed, should be independent of the bag holes, as they are too much obstructed by the bags to afford a sufficient vent. For a 20- or 24-inch main, one 3-inch, and for a 30-inch main, two 3-inch vents should be provided on the gas side of the stoppers for each section of main to be vented. In the job that we already have described, there are four sections of main to be considered. These are the two "live" sections — one between the job and the source of gas supply, and the other between the job and the delivery end of the pumping main. The other two sections, which may be considered as "dead" sections, are the new section which is to be connected to the main, and the old section which is to be cut out from the main. Where the old section is 20-inch or larger in diameter, and over 100 feet long, it is advisable to put a bag or stopper at each end, and insert a bleeder pipe through the bag hole. This will prevent the gas in the old section from affecting the workmen while the main is being cut off. After the cut-out has been made, wooden or metal plugs (B, Figure 21) should be used in each end of the old section.

In the case of the new section, if the main is 30-inch or larger in size, and the section over 300 feet in length, one or two 3-inch vent holes are recommended, as furnishing additional safeguards from any sudden excess of pressure under conditions to be now described.

As pumping mains always begin and often end at stations equipped with machinery for sending out gas under a pressure of several pounds at least, there is always a possibility that, in spite of many precautions, some machinery might be started and some valve opened that would bring sudden pressure against one of the "live" sections of the main being worked on. To furnish instant warning of such pressure, it is advisable that a pressure gauge be installed on each "live" section on the gas side of stoppers, and this gauge be kept under constant observation. Also, a gauge should be installed at each end of a live section terminating at a holder or manufacturing station. By the observation of such a gauge at a holder station, the valve

man would know at once whether anything had happened to cause an increase of pressure in the "live" section. By watching the gauges on the job, notice will be given of any rise in pressure sufficient to endanger the holding powers of bags or stoppers.

A review of the above precautions will show that in case there should be a rise in pressure, accompanied by increased flow of gas to either of the "live" sections, this increased flow, besides being shown by the pressure gauges, could be cared for through the vent pipes on the "live" sections, and also to the extent that there might be leakage past bags or stoppers, through the vent pipes in the new section. These vent pipes in this new section would reduce sensibly any amount of gas tending to pass through the new section. This might be of great advantage, as work of this kind usually is prosecuted simultaneously at both ends of the new section. A case in point is cited where, due to the lack of vent pipes, a bag was blown out of position at one junction of a new section with an existing main, and the men at work at the other end of the new section, which had not yet been entirely closed in, experienced much discomfort from this escaping gas.

Size of Bag Holes

The schedule in use in Philadelphia governing the sizes of holes to be tapped for the insertion of bags and stoppers, is as follows :

Schedule for Bag and Stopper Holes

Main	Bag Hole	Stopper Hole
3″	1 ″	1 ″
4″	1 ″	1¼″
6″	1½″	1½″
8″	2 ″	2 ″
10″	2 ″	2 ″
12″	2½″	2½″
16″	* 3 ″	3 ″
20″	* 3 ″	3 ″
24″	4 ″	4 ″
30″	5 ″	5 ″
36″	5 ″	5 ″

* Use 4″ for heavy canvas bags.

Insertion and Withdrawal

In inserting a bag, the procedure is about as follows: After the hole has been drilled, the portion of the main where the bag will rest is carefully cleaned of any metal cuttings or any con-

densation, the latter often having a very rapid action in dissolving rubber. This cleaning is accomplished by means of waste or cloth at the end of a stick. Where condensation is encountered, it is advisable to protect the bag by soaping it as well as may be. Soap will also help in making a bag hold back gas where the inside of a main is quite rough.

The bag fork (F, Figure 24) is sometimes used in inserting the bag, which is placed in a folded position on the face of the fork, and the bag stem pulled back through between the prongs near the hilt. The bag and fork are then entered simultaneously, the fork serving to force the bag down into the main and away from the hole. After inflation of the bag, the fork is withdrawn. Where there is much more pressure on one side of a bag than another, the fork is of special use in holding the bag in place and in proper position until inflated. In the absence of a bag fork, a stick is used to force in the bag, which is rolled or folded snugly.

A bag is placed properly when the axis, passing through the stem, coincides with the axis of the main. In inflating large bags, a bag pump (D, Figure 24) generally is used. By means of a small bag inserted in the supply line, an indication is given of the degree of inflation of the bag in the main. This also can be told by observing the bag itself through the bag hole.

Large bags have cocks attached to their stems to control the air flow. The stems of small bags are tied together in a kinked position. A small stick should be so attached to the stems of all bags as to prevent the bag being moved from the bag hole. All bags, or stoppers, while in use, should be under constant supervision to ensure that they are maintaining their inflation and position. Whenever a stopper is within arm's length of an open end, clay or soap should be applied at once along the contact line between stopper and main.

In removing a bag, first the air is allowed to escape, and then the bag is pulled out slowly through the opening, first by means of the neck, and then by pulling on the bag itself, the pull always being applied close to the main, and the bag kept rolled up like an umbrella. All condensation should be removed immediately from the bag by the use of soap and warm water.

In inserting a stopper, it is folded neatly and pressed together, and pushed in carefully and slowly, it, as well as the bag, being always a snug fit in the hole allowed by the schedule. The flexible frame and the handle are kept uppermost until the

stopper is completely within the main. The top of the flexible frame is then in contact with the top of the main and a short distance back of the hole, the bottom of the frame is on the bottom of the main, and the axis of the stopper is at an angle of about 45° with the axis of the main. The stopper is now revolved through 180°, and pushed into the hole about as far as it will go, bringing the top of the frame a few inches from the hole. The top is kept in this position, or perhaps forced slightly away from the hole by means of the short handle, while by the long handle the lower end is drawn forward towards the hole, thus bringing the plane of the frame into perpendicularity with the axis of the main, and forcing the frame into a circular shape. When ready to draw the stopper, the lower end is forced back along the bottom of the main, and the upper end is drawn slightly forward, until the frame has assumed its greatest possible length. The stopper is then revolved 180° bringing the frame on top and withdrawn.

Care in Regard to Supply of Gas

Bagging off the supply of gas involves certain operations which, unless proper precautions are taken, may result in a diminution, or entire stoppage, of supply to consumers. These operations are, first, the tapping of the bag hole and any subsequent opening of it, allowing free gas flow; and second, the insertion of the bag, with a consequent interruption of gas flow in the main.

The precautions to be observed in connection with the tapping of the bag hole, of course, apply equally to the tapping of any hole for any purpose, or to any work which makes in any pipe conveying gas, an opening whose area is of appreciable size as compared with the area of the pipe. Experience has shown that if flow is established quickly through the ordinary hole tapped in the average size main, the diminution in pressure caused thereby may be quite sufficient to put out lights turned low, and that the quick uncovering of the opening causes the pressure in the main to fall momentarily to a point lower than is caused by the steady flow of gas through the opening. Of course, the amount of effect produced in any main, that is, the distance on each side of the opening to which the effect extends, and the extent of pressure lowering, depend entirely upon the relation between size of main and of opening, and the conditions affecting the supply of gas into the main. However, such

serious results may ensue from unlighted gas issuing from burners, extinguished by a lowering of pressure because of the careless tapping of holes and their uncovering in putting in bags, that it is wise, especially in cities and large towns, to observe the following precautions.

When any opening is made between a main and the atmosphere, so that gas may escape from the opening, the plug, tap, or fitting, whose removal makes the opening, should not be moved away from the main at right angles to it, but should be moved sidewise over the opening, and kept in close contact with the main, and as it is moved off the opening, the fitting, or plug, which is to take its place, should be moved on. Neither motion should be rapid or sudden. The result will be that at no time is the whole area of the opening exposed for the escape of gas, and also that there is no rapid change in the area through which gas is escaping.

When a hole has been tapped for the insertion of a bag (or stopper) and the bag is to be inserted at once, in removing the tap from the main, it should be slid sidewise over the hole and followed immediately by the hand, placed in such a position as to encircle partially the receding tap, and to block off the escaping gas as far as possible. In inserting the bag, the hand should be moved slowly over the hole to afford room to insert the end of the bag, and the hand should continue to cover the hole as much as possible, until the latter is filled by the bag. As the bag gets further in and begins to taper off towards the top, the hand should again be placed over the hole and kept there until the bag is inflated. In withdrawing the bag, the same precautions should be observed in reverse order, and, in general, everything done which will decrease the absolute rapidity of gas flow, and the rapidity of change in amount of flow.

The practice described above should be followed in mains of all sizes. In addition, where the main is 3-inch or smaller, or is supplied from one end only, and any portion of this sole supply is 3-inch or smaller, a pressure gauge, as shown in Figure 78, should be connected with the main so that any pressure drop can be noticed, and if at any time as little as 1-inch pressure is shown, then an examination must be made in the neighboring houses to make sure that no lights have been put out. In general, in any work involving possible interference with the evenness of gas flow, any nearby street lamp supplied from the

main in question should be lighted, as its flame will be a valuable telltale of what is happening in the main.

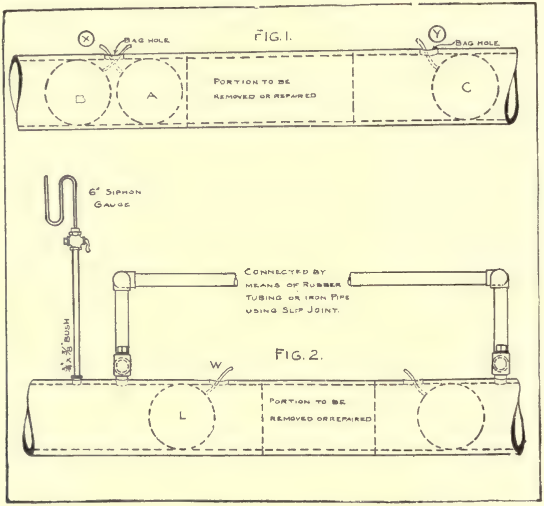

Figure 78. — Arrangement for Bagging Mains, page 268.

Discussing now the second precaution, viz., what will be the effect of the insertion of the bag in that portion of the main which must not be deprived of gas, the whole question hinges upon what is *known* of the main connections in the region in which the work is being done. Where the records are perfect, and show that a main is connected at both ends, then in the absence of a stoppage, such as water in a trap or a drip, or some other obstruction, a bag, or bags, may be inserted with confidence that the result will be the stoppage of supply to that section of main only whose isolation is desired.

If, however, it is necessary to bag off a portion of a main which is not known positively to be supplied from both ends, the work should be done according to the following directions, as illustrated by Figure 78. Place a bag (or stopper) through the hole

at "X" in the position "A," *Fig. 1*, judging the flow of gas toward the bag by noting the speed of the gas escaping from the bag hole. The escape of gas thus permitted should be brought on gradually, for reasons already explained. If no drop in pressure is noticed, deflate the bag, inflate in position "B" and test for flow of gas as before. If this test indicates a satisfactory flow, leave bag in position "B." Another bag inserted through bag hole "Y" in position "C" completes the operation of isolating the position of the main to be repaired or removed. The tests at "X" have demonstrated that gas was being supplied in both directions, and that, therefore, no by-pass is necessary.

If on making the test with bag in position "A" or "B," a drop in pressure is noted, indicating some obstruction or a dead end, the bag should be left in position inflated until the extent of the section deprived of gas is ascertained and the meter cock in each house closed. (This same routine should be followed in any case of bagging off a main where it was discovered that gas had been shut off from a section not meant to be isolated.) Having done this, the bag may be deflated and gas again allowed to flow into the section unintentionally isolated. Before resuming the work necessitating the bagging, a gauge, *Fig. 2*, should be attached to the section previously isolated and a by-pass laid around the section to be bagged off. Observations of the gauge should be made while inserting or removing by-pass, bags, etc. If at any time the pressure falls below 1 inch, the gas should be shut off immediately from the section so affected, and an examination made of each house as already described. *Fig. 2* shows the position of the bags and by-pass when ready to cut out or repair under the conditions already described, — in other words, the arrangement necessary when the main is fed from one end only.

When withdrawing the bags in the arrangement as shown in *Fig. 1*, on completion of the work, the bag (or bags), first inflated, should be drawn first, and the resulting pressure noted. In this way, if by any chance the supply of gas has been cut off unknowingly on the side of the section bagged off first, this fact will be shown at once on withdrawing the bag, by the entire absence of pressure, and the proper precautions can be taken. When, as in *Fig. 2*, a by-pass is in use and in place, the first bag inserted should be at "L" in the dead end supplied by the by-pass, being placed as shown on the side of the hole away from the section to be repaired or removed. This bag

must be the last one withdrawn, for the full supply of the main, in addition to the by-pass, must be available to the dead end section as the last bag is being deflated, or otherwise the escape through the hole "W," even with every care exerted, might be so great that the supply through the by-pass could not keep up the pressure in the dead end section.

Purging

The operation of "purging," i. e., filling a main with gas, may be either very easy or very difficult, according as there happens to be a small length of main, or an extensive system to be dealt with. In every case, however, care is needed to prevent any chance of ignition of the explosive mixture of gas and air issuing from the main being purged.

In its simplest form, as applied to a stretch of ordinary sized main ending in a location where a little gas smell is not objectionable, purging consists of removing a screw plug from a hole tapped in the main at the end farthest from the source of supply, and allowing, first, the air, and then, the mixture of gas and air to blow into the atmosphere until it is believed, or found, either by smell, or by sampling the issuing gas, that all the air has been removed. The advisability of sampling increases with the size of the main, and with the chance of the mixture of gas and air being supplied to consumers before any other operations tend to produce a flow of gas through the main in question, and, therefore, to reduce the air to a negligible percentage.

The sampling may be accomplished by filling, with the issuing gas, a deflated rubber gas bag, and then removing the bag to a safe distance, inserting a pipe with a burner attached, in the stem of the bag, squeezing the bag and lighting the stream issuing through the burner. The color of the flame will indicate the degree of purity of the gas.

With an increase in the size (and to some extent, the length) of the main will result an increased volume of gas and air to be discharged into the atmosphere, before purging is complete. This often will mean the advisability of a standpipe screwed into the outlet hole, and discharging above the heads of pedestrians. Also, as the period in which an explosive mixture exists is longer than with a small main, the use of wire gauze in the standpipe is a wise precaution. This gauze prevents any flame which might ignite at the standpipe end, from flashing back into the main.

In every case of purging, the precautions already spoken of under "Care in Regard to Supply of Gas," page 266, should be

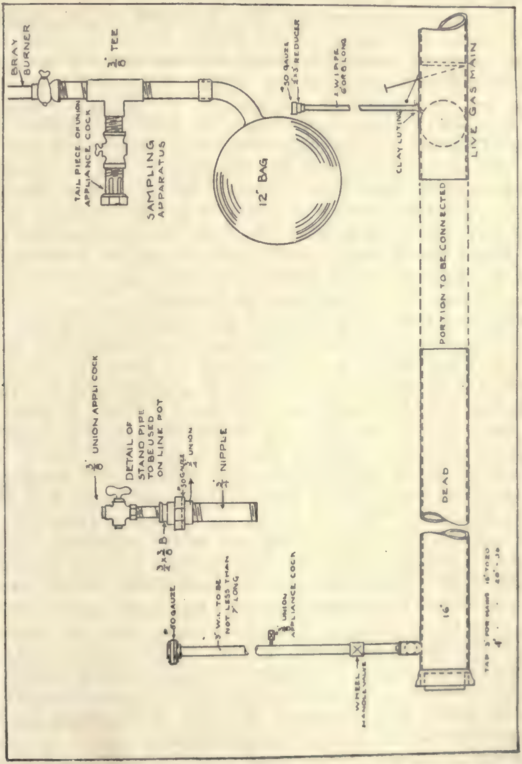

Figure 79. — Method of Purging Large Mains, page 272.

carefully observed. After the main is properly purged, the plugs of all drip standpipes should be removed, to allow the escape of any air that might be pocketed in the lower portions of the drip pots.

An arrangement that has been used in Philadelphia on mains 16-inch and over, is shown in Figure 79. The convenient method for sampling the gas will be noted.

Very rarely it may happen that the main to be purged is situated where the escape of gas would create a considerable nuisance, as in a crowded business thoroughfare. If so, and it is not advisable to purge until the smell comes, and then stop, trusting to the sufficient admixture of the air remaining with the gas, to prevent any chance of lights going out, or of very poor illumination, the only remaining course is to burn the issuing stream at the top of the standpipe. With a gauze of mesh as small as that used in safety lamps, and a standpipe equipped with four successive sheets of gauze, arranged in two pairs, 2 feet apart, each sheet of a pair being separated by a ½-inch gasket, there would seem to be no risk of any flashing back in the main, if care is taken to observe that the pipe is not becoming warm, for a reason now to be told.

In supplying New York city with gas made on Long Island, it happened that 50 miles of mains were laid before the tunnel under the East River was completed. Therefore, this main system had to be purged more or less as a whole, and it actually was purged in two sections. It was decided to burn the gas in order to be sure that all of the air had been expelled. Standpipes with four gauzes, about as described above, were used successfully on this occasion and also on each subsequent addition to the main system, until one day, when purging about a thousand feet of 20-inch main, an explosion occurred, due undoubtedly to the flame at the end of the standpipe flashing back into the main. The only explanation for the passage of the flame back through the four sheets of gauze, would seem to be that the flame first flashed back to the upper pair of gauzes, and burned above them so long as to make them red hot. In this case the flame would travel down to the second pair, and after they became red hot, an explosion could occur if the mixture was still explosive. An observation of the temperature of the standpipe would have disclosed the fact of the flame burning on the gauzes and the danger being incurred.

A feature of purging, where more than a single line of main is in question, is the necessity for bagging at certain points to prevent large pockets of air. For instance, when one or more of the mains is fed from both ends, three holes, with a bag in the centre hole, will allow the air to come both ways to the bag,

and issue out of the other two holes without forming any pocket. Naturally, in work of this kind, the tightness of the bags is very important, and each such bagging place should be under the continuous surveillance of a reliable workman.

Maintenance of Gas Supply During Main Laying

Importance of Maintaining Supply

So far, in discussing the question of main laying, it has been assumed that the work involves an extension into new territory. Many mains are laid, however, to replace existing lines, and in these days of the extensive use of gas for heating and other domestic and industrial purposes, it often is imperative, with any due regard for the rights of the consumer, that any cessation in gas supply be as short as possible. This means, to begin with, that gas supply be kept up through either the existing main or temporary main, until the new main has been purged. If gas is maintained in the existing main, but this must be disconnected from its ordinary source of supply to allow the connection of the new main, then a by-pass must first be installed across the gap. It also means that the transfer of old service to new main, or from old main and old service to new main and new service, should be done expeditiously.

In considering this work, three different conditions will be taken up in turn: first, where the existing main is not in the way of the new one, and, therefore, can be kept in use until the main has been purged; second, where the existing main must be removed to make way for the new one, but prior to such removal a temporary main may be laid; and third, where the existing main must be removed, but no temporary main is feasible.

Supply By Existing Main

Where the existing main, whether or not exposed in the trench made for the new main, may continue to supply gas until the new main has been purged, the work of main laying is not much more difficult than in the case of a new extension, except for what support may have to be provided for any section of the existing main that may be exposed in the trench. At this point, it should be stated that the value of the iron recovered, even at scrap prices, generally makes it an economical proceeding, other considerations being equal, to lay the new main in such a location that the existing main may be removed with no, or only a slight amount of, additional excavation.

Before the new main is purged, all necessary service holes should be tapped and service renewals made to within the cellar wall. Then, in the case of a consumer whose service is renewed, the discontinuance of gas supply will only cover the time necessary to transfer the piping on the inlet side of the meter from the old service to the new one, which may involve only the unscrewing of the existing inlet connection, and the screwing of a new inlet connection attached to the new service. When the service does not need renewing, there will be necessary, in addition to the work inside the cellar and preceding it, the cutting of the existing service and its reconnection to the new main. The above service details apply equally as well to the paragraphs that follow.

Supply by Temporary Main

Where a temporary main is to be laid, its size should be determined from accurate knowledge of the maximum demand of the consumers to be supplied. Usually a 2- or 3-inch main will be amply large, and steel generally is preferable to cast iron for any size smaller than 8-inch. The usual location is above ground and close to the curb, either in roadway or on footway. Tees forming part of the line of pipe make the best method of service connection. Each tee is joined by iron pipe, or by pipe and armored rubber hose, to one of the existing services. This involves a cessation of gas supply while the service is being cut off from the existing main and connected to the temporary main. Generally, the connection to the service will be made outside of the curb cock, but even in that case, it will be advisable, when using hose connection, to put a cock between the hose and the outlet from the temporary main. This second cock allows a quick shut-off in case the hose connection pulls off or in any way develops a leak not capable of quick repair.

The temporary main usually will be supplied with gas through one (or preferably two) connections tapped into the existing main system. In the case now under consideration, viz., where a temporary main is used only during the laying of a new main, it is seldom necessary to make any provision for condensation in the trap formed by the service connection above described. Where, however, temporary mains are laid because of the forced removal of permanent mains during the progress of street work, and temporary supply will continue during cold weather, ample drip provision should be made at any trap.

Figures 80 and 81 illustrate some features of temporary main work.

Figure 80. — Temporary Main, page 275.

SUPPLY IN ABSENCE OF ANY MAIN

The cases in which the existing main must be removed to allow room for the new main, no temporary main being possible, and consumers were using gas at all hours of the day, would prove undoubtedly to be very rare. Where the existing main was fed from two directions, it could be cut out at the end from which the new main was being laid without installing a by-pass. Then the problem of main laying would consist in removing the existing main in as small units as seemed practicable, and in purging the new main in small sections as laid and joints made. Holes for services would be tapped in the new main before laying, and would serve as successive purging and bag holes. In this way, no consumer need be out of gas more than one or two hours, and by special expedients this time could be reduced greatly. For instance, a temporary pipe might be run from the top of the street tee in the last service on the new main, to connect with the

Figure 81.—Temporary Main, page 275.

service, or services, being disconnected from the section of existing main just taken out to make way for the next section of new main.

Where the existing main was fed from one end only, and this was the end from which the new main was laid, a by-pass would, of course, have to be installed to feed the existing main, and with the progress of the new main, the position of the by-pass would be changing continually.

CHAPTER XXVI

REFILLING AND REPAVING TRENCH

Refilling

General Considerations

In refilling, there always is an opportunity of skimping work,—entirely absent in the case of trenching. The great saving in labor afforded by loose filling or puddling, as compared with tamping and ramming, often results in the adoption of one or the other, where not only the best interests of the work, but also of the public, require that ramming should be done. In discussing the conditions that should be kept in mind in deciding on any particular method, this general rule should never be forgotten, viz., that the public has a right to expect such refilling as will restore, as promptly as possible, to its original condition, the surface of any trench in any roadway where traffic is incommoded seriously until such restoration is complete.

Unless the expense is very great, only good soil should be in close proximity to a main, and should cover it by a layer six inches to a foot thick. This is important especially where the main is of wrought iron or steel and the good soil is substituted for ashes, cinders or city refuse. Cast iron is not nearly so likely to corrode, but still good soil around it is advisable. The objection to refilling with small or large stones or broken rock, depends entirely on the question of future repairs. If the trench is not apt to be opened to any great extent, as would be true of most small main jobs, a large expense for soil to replace the excavated rock would not be justified. However, it often happens when solid rock is encountered, that the excavated material can be sold on the trench side at a slight profit, thus paying for the substituted earth.

During the winter time, before refilling, any frozen excavated earth should be broken up as far as feasible, because in this way more material may be returned to the trench and less

settlement is likely to occur after the frost goes out. As far as possible, unfrozen material from the centre of the pile should be placed around the pipe. When other conditions are acceptable, and the temperature is above freezing, puddling may be used to advantage with frozen material.

The character of the temporary surface over the trench in those cases where repaving does not follow immediately upon refilling, will vary with the kind of paving, and is discussed under "Repaving," page 284.

Ramming

Ramming should be the practice wherever there is much travel along and over the trench, or where repaving must follow immediately. It is accomplished by tamping and ramming solely, or in combination with puddling.

If the main has been laid with cement joints, dirt has been tamped under and alongside, and rammed on top, of the pipe for a depth of several inches, except at the bell holes. If lead has been used, the amount of refilling that has been done prior to the completion of laying work, will depend upon the necessity for strengthening the trench or keeping the laborers busy. In any case, the first refilling after the pipe has been laid, tested and purged, should be over any uncovered portion of pipe, and where compact filling is necessary, there should be for every shoveler on the bank, two men in the trench, tamping (A, Figure 19) the earth under the pipe, and between it and the trench sides. The tamper should be exchanged for a rammer (B, Figure 19) as soon as there is sufficient room in which to use the latter tool. When first tamping around a pipe not held in position by any earth, the tampers should be in pairs, one on each side of the pipe, working against each other and thus preserving the alignment. Both in tamping and ramming, the lowest points in the trench should be refilled first, and thereafter the refilling carried on in horizontal planes.

For any mains larger than 12-inch, an economic width of trench for all laying purposes will not afford enough room on each side of the pipe to ensure that the space between the bottom of the main and of the trench is filled even loosely, and, therefore, unless there is a willingness to incur extra excavating expense, it must be understood that under all large mains there will be a space of varying dimensions, which will afford a gas leak a fairly free passage. However, this is about all the harm done,

with the resulting chance of making the exact location of a future leak somewhat harder. If the main is blocked properly, it will not settle, and if the trench elsewhere is filled properly, the hollow under the main will cause no earth settlement. Nevertheless, because it is impossible to fill entirely the space under the main, this does not mean that no effort should be made to fill as much space as tools and trench will allow. The larger the main, the more the attention that should be paid to this first tamping, and the better the laborers assigned to the work.

With a proper proportion of rammers to shovelers, and the right kind of rammers, viz., men able, and paid, to ram *hard*, there usually will be no difficulty in replacing all material removed for mains 8-inch and smaller. On larger mains, where earth has to be hauled away, an accurate account should be kept of such removed material, and if it exceeds the volume of the pipe laid, an explanation should be forthcoming from the foreman.

In recent years, power rammers, driven by gasoline or compressed air, have become available, and have now passed the experimental stage. With the increasing difficulty of procuring good labor, the value of such machines, both as labor-saving devices and as ensuring proper ramming, will increase. In turn. the enlarged demand will bring about new developments in the machines, still further increasing their usefulness. Figure 82 illustrates a satisfactory type.

In any refilling, but especially in ramming, care is necessary to protect from injury all small pipes exposed in the trench, especially any lead water-services. These, where over the pipe, should be blocked from it, or, if under, from the trench bottom. In either case, the blocking tends to prevent any pressure of the earth pulling the lead pipe out of the main. Ramming over terra cotta pipe should be done carefully, to prevent a smashing in and possible stoppage.

If the trench is to be paved at once, refilling should stop at the point below the surface where the paving base begins. Otherwise, the trench should be filled to the street surface, or, at the most, only slightly mounded. If, for any reason, material is lacking, enough should be procured to leave the trench surface flush with the rest of the roadway.

Occasionally, in trenching, it is advisable or necessary to tunnel under certain paving or structures. These tunnels

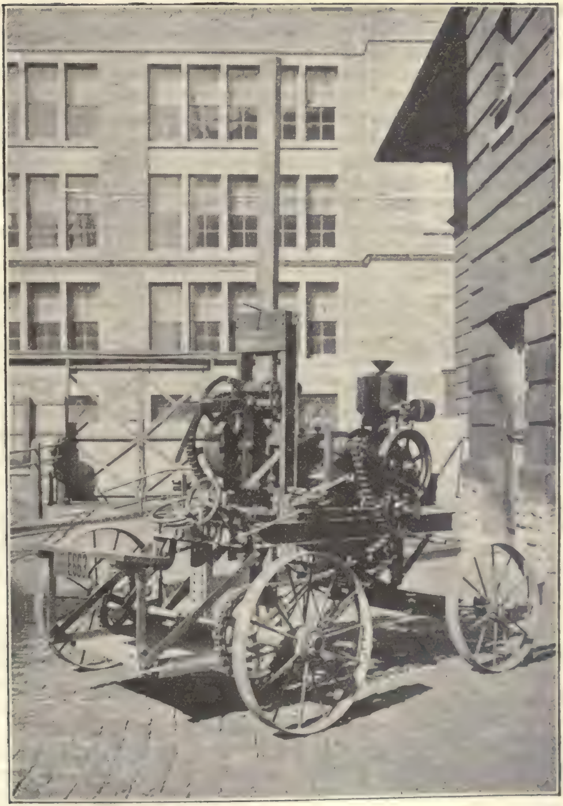

Figure 82.—Tamping Machine, page 280.

usually exist in connection with trenches refilled by ramming or puddling. Ordinarily, it is more economical to break down the tunnel roof than to refill from the sides. Of course, where struct-

ures such as street railroad tracks with concrete roadbed are concerned, breaking down is not the right course.

Puddling

Puddling appeals to every foreman because of its cheapness, and should be practiced wherever the conditions are favorable, viz., where the soil is of the right kind, and there is no danger of water soaking into cellars, or undermining the pipe. Puddling in a street made of filled-in material, may cause a general sinking of the street surface. In built-up sections, puddling may be objectionable because of the chance of water getting into cable conduits, or because of the inability to pave at once upon the puddled material.

When puddling, the pipe should be covered at least six inches by well-rammed earth before any water is let in. Also, if the trench has over 5 per cent grade, the first ramming should reduce the grade to this figure, in order to prevent any wash under the pipe by water sinking through the loose fill. Dams at frequent intervals also will serve to prevent any scouring out by water flowing down a grade, and in any case, dams would be necessary to confine the water to each terrace made by the first ramming.

After the preliminary ramming, the trench is filled to within about one foot of the surface, and then water turned in, usually from the nearest fire hydrant, the keys for which are furnished by the municipal authorities, often on payment of an annual fee. Care always should be taken to avoid injury to paving by the flow of water over it. As the water flows along the ditch, bars are hand driven through the loose material into the rammed earth alongside the pipe, and swung around in a circular direction. The funnel-shaped holes so made allow much water to soak into the earth around the pipe, and perhaps carry earth to fill any voids under the pipe, but there is no chance for a flow of water rapid enough to affect the stability of the pipe. As the earth sinks under the action of the water, more earth is added, especially when needed to preserve any desired channel for water flow which is not stopped until the saturated earth will absorb no more. Then the remainder of the earth is thrown in and lightly rammed into a slight mound over the trench surface.

Too much ramming is objectionable, as it tends to produce a spongy condition. Too much water also is to be avoided, as this softens the bed of the trench, causes the pipe to settle and makes

the refilled material so soggy as to delay repaving. Ordinary labor cannot be trusted unwatched on work of this nature.

The method above described is considered preferable to the practice sometimes followed of throwing in all the earth and digging a trench in the centre of the mound for the water to follow. This leaves no dry earth to finish off the trench.

Where services are laid in connection with the main work, especial care should be given to the repair of the opening made in the house wall, if there is to be puddling and the water line will be higher than the service opening. Of course, the more porous the soil, the more reason for a good cement coating, both on the outside and the inside of the wall. Also, a dam of dirt should be thrown across every service trench at its junction with the main trench.

Loose Filling

Naturally, the largest amount of main work will consist in extensions to the existing system made necessary by new buildings, and usually such extensions are laid in unpaved streets. With the ordinary sized main, and an interval of some months elapsing between laying and paving, there can be no objection to loose refilling of the trench, leaving its gradual consolidation to time and street traffic. In such unpaved streets there always are many trenches beside those made for gas purposes, and the roller used by the paving company is relied on to compact the entire roadbed.

The surface of this trench after a loose refill is that of a mound perhaps a foot high. This serves as a warning to wagons to keep away. It is incumbent on the gas company to make a frequent enough inspection to ensure the prompt filling of any dangerous holes that may be formed after a hard rain. Also a certain amount of trimming of the mounded earth may be required from time to time.

Cleaning Up

The final cleaning up after any main laying job can take place only when repaving is complete, but as in many cases the repaving is done by a contractor, such cleaning up as may be done before repaving, and by the company's employees, will be treated of now.

Almost any one can open trench and obstruct and dirty a street and footway. Few contractors on street work ever clean up properly. All gas companies should see to it that the natural

disgust induced in the occupants of any street at seeing it torn up, is followed, as quickly as possible, by a feeling of satisfaction at the prompt execution of the work and the thorough restoration to previously existing conditions. Water and a broom are aids not often enough used in the final stages, but they generally are needed to do justice to the occupants' properties in the removal of all earth stains on house fronts, sidewalks, tree trunks and boxes, grass, etc.

In this connection, good planning of a job, to be sure the difficult portions are not neglected, will do wonders to make the work move along continuously and not leave many gaps remaining open for days after the work on each side is finished.

Repaving

General Considerations

It is not considered advisable to describe the art of paving, and this not only because it would add to a treatise already very long, but also because many companies find it advisable to contract their paving. This tendency is increased by the growing prevalence of asphalt, the restoration of which by the company is out of the question. In the old days, when cobble and rubble were alone met with, a few paving tools and a little sand were the only equipment needed to enable every main and service gang to restore their own paving.

So far only roadway paving has been in mind. A like change has occurred in the footway. Bricks have given place to cement, and, again, the new form requires more skill and equipment in its restoration than did the old. Therefore, as has been said before, the tendency is to contract for the paving. This involves more lamping of trenches, rather more office work in connection with paving bills, and possibly more inspection of paving work, though with reliable contractors, their work need not require any more attention and inspection than would company paving. By inspection, two results are obtained: No poor work is allowed to remain as an annoyance to the public and a bad advertisement for the company, and no dangerous holes may exist long without detection. As the details of an inspection system will vary greatly according to local conditions, no description of one will be given here.

Asphalt

If the street is a much travelled one, it is advisable to leave the trench in such shape that it may be driven over during the

interval between refilling and repaving. This condition has an added advantage that it dispenses with the expense of lamping the trench. When the material has practically all gone back, the concrete of the base (if any) should be thrown in on top of the earth, and then the asphalt pieces laid down. If the pieces have been well cut, a very good job can be made. In some cases of service trenches on important streets, with extra care in cutting the asphalt, and the use of a little cement in the cracks between the pieces, a very fine temporary job results. Again, the base material may be left along the trench or at the curb in piles, and just the asphalt laid back, or the asphalt may be left piled up and the trench surface finished off with the base materials. In most cases, however, it probably is true that the surface of a long trench cannot be economically made safe for bicycles or motor cycles, and if there is much of such traffic, it would be necessary to lamp the trench until repaving.

In order to ensure prompt repaving, it is advisable to provide in the contract for decreased prices for all delayed work. For instance, if paving is supposed to be laid within four days of receipt of notice, seven-eighths price might be paid for paving laid five days after notice, three-quarters price six days, etc. Also, the use of concrete base under all asphalt, whether the original paving had such base or not, will result in a gratifying absence of settlement, — a condition always glaringly apparent in asphalt.

In towns without any asphalt plant, it generally will be satisfactory to the municipal authorities to substitute a cement finish on a concrete base for any asphalt torn up, this being regarded as temporary repaving only, and being replaced on the first occasion that asphalt material is available.

Concrete Base Paving

Most modern street paving is laid on a concrete base, and the tendency with this class of paving, as with asphalt, is to intrust its restoration to a contractor. Usually, the more or less broken masses of concrete form the surface of the trench as left by the refilling gang. Whether such a trench will need lamping or not until repaved, will depend on its location, the compactness of its top surface, the amount and character of traffic, etc.

All Other Paving

Under this head falls vitrified brick, belgian block, cobble and rubble, all on sand base. Where only small openings are made

in such paving, there are many arguments in favor of its restoration by the same gang that did the opening. In other words, on detached service or leak work, the ability of the gang to do its own paving will save all lamping cost, as well as a constant expense entailed by unpaved trenches, such as water in cellars. Also, it is possible to get better paving done by the company's men than by the contractors. When opening up a street requiring sand between the paving stones, one of the obligations of a gas company, to insure a good job, is to see that such sand actually is brushed in between the stones, and not left on top to be a nuisance on windy days.

As a rule, however, the fact that much of the paving is better contracted for will incline the average company to contract for all. In doing so, a bigger profit often is paid to the contractor than is realized, until it is found by experience how cheaply, with proper organization, sand base (and even concrete base, if there is enough of it) paving can be done.

Below is given some information as to equipment useful in paving work:

PAVING SMALL OPENINGS AROUND STOP BOXES, ETC.

1 Light Push Cart (Figure 53, page 178) containing:
- 1 Spoon Bar (C, Figure 44, page 166),
- 1 Street Broom,
- 1 Small Galvanized Bucket,
- 1 6-inch Cold Chisel,
- 1 Stop Box Cleaner (A, Figure 45, page 168),
- 1 Brick Hammer,
- 1 Caulking Hammer,
- 1 Pick,
- 1 Sharp Nose, D-Handle Shovel,
- 1 6-inch Trowel,
- Cement, sand and bricks.

PAVING SERVICE AND SMALL MAIN OPENINGS

2 Street Bars,
1 Mixing Board, 3 by 4 ft.,
1 Street Broom,
1 Dust Brush,
1 Galvanized Bucket,
2 Cold Chisels,
2 Diamond Points,
1 Rake,
1 Belgian Block or Paving Rammer,
1 Dirt Rammer,
1 Dot Roller, for cement,
1 Seamer,

1 Paver's Straight Edge,
1 Curb or Radius Edger,
1 Wooden Float,
2 Brick Hammers,
1 Caulking Hammer,
1 Concrete Knife,
2 Picks and Handles,
1 Pitchen Tool,

1 Flat Nose, D-Handle Shovel,
1 Sharp " " "
1 Sieve,
1 Finishing Trowel,
1 4-inch "
1 8-inch "
1 Monkey Wrench.

Paving supplies, such as cement, brick, crushed stone, etc.

This equipment is sufficient to do, on a small scale, all kinds of paving except asphalt.

Paving Large Main Openings

For extensive paving, the number of tools listed just above is increased, depending upon the amount of paving to be done.

CHAPTER XXVII

RECORDING

Reasons for Records

A knowledge of the number of feet of each size of pipe comprising the street main system is valuable at all times, and very necessary when a valuation of the mains is required. This knowledge, subject to varying degrees of error, is possessed by every company, and almost always presupposes the possession of a map showing the location of the mains by sizes. In many cases, however, not only is there great uncertainty as to the correctness of the sizes shown, but also the location as measured from the property or the curb line is either wanting or incorrect. This lack of proper records often is the natural consequence of the fact that in the beginning the location and size of every main was easily a matter of memory for the few employees. As the system grew and new employees succeeded the old, there was failure to transfer records from brains to paper. Another reason for no records, or improper ones, is carelessness in past years in preserving and entering the information furnished when the main was laid.

At present, the necessity for proper street main records is appreciated thoroughly, and the problem has been solved in many different ways, depending upon differences in local conditions and in the human equation. In what follows will be found a description of methods, the use of which has proven their worth.

System of Records for New Mains

In determining the character of requisite street main records, the usual condition is that of a main system sadly lacking in data regarding existing mains, and, therefore, needing records of maintenance as well as extension work. Before considering this condition, the less common one will be discussed, where an entirely new main system is being installed.

Field Records

For the field record, that is, the one taken out on the work, a transit book is very convenient. This is $4\frac{1}{2}$ by $7\frac{1}{8}$ inches, has about sixty leaves, and is ruled with horizontal and vertical lines. In making the records, a zero point may be taken at the beginning of the line, and all locations along the line given with reference to this zero. For long lines, especially in country roads, this is the best way, and it also is very convenient in city streets. Following this method, once the proposed line of a main has been measured, and the position of all desired points of reference noted, any portion of the main as laid can be shown quickly on the record, no matter whether gaps occur or not.

The amount of record that will be needed to enable the main to be located properly on a map, and also found easily where occasion requires uncovering, will depend entirely upon the number of changes occurring in depth and alignment. The depth to top of pipe and the distance out from the curb or property line, should be given every hundred feet when there is no change; and where the dimension is changing, at enough points to define the line. A single line will suffice to show the pipe. All special castings, whether branches or bends, should be located accurately, the length of each special being considered to be the distance between the faces of its bells, where it has two bell ends, or between the bell of adjoining pipe or specials, when the special being measured has two spigot ends, or between the bell of the special and the bell of the adjoining pipe or special, where the special being measured has one bell and one spigot end. A bracket mark ( ]), at right angles to the length of the pipe, is an easy way of representing the face of every bell, the horizontal lines extending away from the face of the bell.

When the points of reference along the main, such as dividing property lines, intersecting roads or streets, etc., are not at right angles to the main, these points should be located by their intersection with whatever line is being used as a base to measure distances at right angles to the main, and not by their intersection with the main itself.

With all specials thus located at the proper distance from the assumed zero point, the amount of straight pipe laid at any moment may be calculated easily, and, in some cases, this is an easier way of getting it than by adding up a series of figures showing the work day by day. Any portion of the line, where the depth is changing rapidly, or where the pipe is not parallel to

the reference line, must be measured along the pipe itself, and such measurement recorded and used, instead of the distance as measured on the reference line, between the stations marking the beginning and end of such deviations in line and depth.

When there are many specials in close proximity, which usually means many changes in depth and alignment, the scale sufficing for the ordinary portions of the line will prove too small. Therefore, either the scale ought to be increased at these points to give a proper sketch, or else a detail sketch on a larger scale should be shown elsewhere.

While, as a rule, the depth would indicate which way the line was dripping, at the same time it is surer, and much more convenient for purposes of permanent record, to indicate the direction of drippage by an arrow parallel to the line and pointing with the flow.

A record of other structures encountered is generally of sufficient value to warrant the slight extra work involved in making such record. This record of foreign structures increases in value as underground conditions become more congested, and when there is another gas company, whose records probably are not very complete, any records of its mains are apt to prove very useful, either in competition or consolidation. Where the foreign structures are mains, they can be indicated in the same way as the main being laid, though probably not in so much detail. Where they are conduits, and, therefore, almost invariably rectangular in section, a line may be drawn indicating the nearest upper edge to the main being laid. This, in connection with the distance from the centre of the main, the breadth and depth of the conduit, and the depth of its top surface below the street level, locates it completely.

It is of value to indicate on the record the date on which each foot of main is laid. This is done very easily by placing the date of each day's work between arrow heads, located at the proper points. Where, for any reason, the work is quite discontinuous, the graphical record of dates may prove quite valuable as a history of progress and of work condition from day to day.

Figure 83 shows two opposite pages of a transit book with its record.

Reports to Office

Where the company is a small one, no work-progress report to the office is needed, as the information can be obtained by an

inspection of the field-book, or is a matter of personal knowledge with the main foreman. When these conditions no longer obtain and a daily or weekly report is needed, a form as shown in Figure 84 should be used, printed on a postal card where mailing

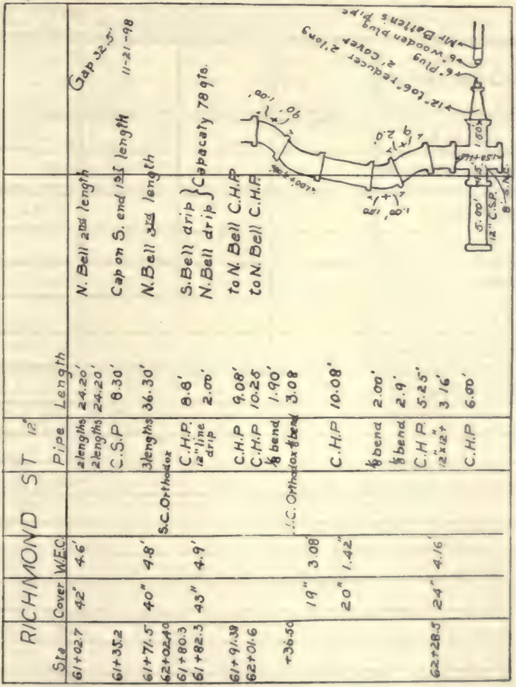

Figure 83.—Transit Book, page 290.

is necessary. "Repaved" shows the total number of feet repaved to date; "Back Filled," what has been filled but not repaved; "Pipe Laid," the amount of pipe laid where trench has not been refilled; "Trench Open," the amount open in which pipe is not yet laid; "Pipe Strung," the number of feet of pipe delivered on the work and not yet laid. This information is

SURVEYOR'S REPORT

________________ 191 __

LOCATION				
SIZE				
TOTAL LENGTH				
REPAVED				
BACK FILLED				
PIPE LAID				
TRENCH OPEN				
PIPE STRUNG				

REMARKS:

____

SURVEYOR

Figure 84.—Postal Card Progress Report, page 291.

valuable particularly in the case of a long line, and gives the office a clear idea of what the physical condition of the work is at the time of report.

Permanent Records

The best form of permanent records for the conditions we have been considering all along, viz., an entirely new system, will depend somewhat upon the maps already available. For all large and many small cities, atlases generally may be obtained with plates whose scale varies from 200 to 500 feet to the inch. There are very few small towns for which maps are not obtainable, and in the country there often are available the maps of the Geological Survey. No company should make up its own map except as a last resort, for map work easily runs into great expense.

On the map, a line will indicate, by its color, the size, and by its position, the general location of a main, but the scale will be too small to make it advisable to indicate specials, drips or any other details. To get such details, a different set of records is wanted, except, indeed, in companies selling, say, less than fifty million cubic feet a year, in which the original field book record will, with the map, supply all necessary information. If the field-book is used, the map should indicate the field-book number and page containing the record of every block, or, say, 500-foot section of main. In this way the map becomes an index for the detailed record.

If the field-book information is transcribed, the desirable unit for the new detailed record is either the city block, or, on country roads, for lines under 1000 feet, the total length of main, and for lines over 1000 feet, some fixed distance, such as 500 feet. The material used for the record should be tracing cloth, or thin bond paper, blueprints from which form the working file, while the originals themselves are kept in a fireproof safe. Each sheet should be about 7 by 18 inches, should give the main in plan and elevation, and be a faithful transcript of the field record in every point necessary to give a proper idea of the location of the pipe and of other structures. The drawing need not be to scale, and thus speed may be gained, and more space afforded for showing specials. Each sheet should be numbered, and the various sheets numerically arranged in groups of one hundred. The general map, or maps, would, in this case, bear the proper record numbers opposite each block or unit distance. Thus, to

find any detailed record, it only would be necessary to look at the map, see the block number, and turn to the proper group of detailed records, where would be found the record desired in its numerical order.

Where there is much occasion to refer to the detailed main records, the above system is exceptionally valuable, because of the quickness with which the records may be found. Where, for any reason, such as, for instance, to locate a main for a service gang, it is necessary to send a record on the street, a convenient way is to make, in triplicate (by means of carbon paper), a rough free-hand sketch, using a white scratch pad $5\frac{1}{2}$ by $8\frac{1}{2}$ inches; give all three the number of the office record; send one sketch on the street, and file the other two numerically. The service man should be instructed to return the sketch, and no other sketch need be made for that particular location until all three are lost or worn out.

Where the record may be needed on the street by the main foreman, there is, of course, no reason why the proper blueprint should not go out, but for service work the sketch system is preferable.

System of Records for New and Existing Mains

Small Company

Coming now to the condition that confronts the average distribution man, viz., a main system that is being enlarged every year, and that also is lacking in proper records of many existing mains, two systems of records could be used, one for the new mains as already described, and another system for the old mains of unknown location. Where the company is selling less than fifty million cubic feet annually, which means a small town with few underground structures and few specials in the main system, one of the most convenient and easy ways to record information of old mains as obtained from time to time, and to collect this information in a convenient shape from which to make a graphical record later on, is by the use of the book, of which a specimen page is shown in Figure 85.

The book was written up for every street on which mains were known to be, and distances shown between each intersecting street. As illustrated, zero is the east fence line of Erie, and 202 the east fence line of Huron, which is also taken as zero for distances in the next block. One line of the book was allowed for every 25 feet, and any work done on a main, or information gathered

3 INCH MAIN			HIGH ST.					NORTH SIDE	
LOCATION	MAIN LINE		DESCRIPTION OF BRANCHES.	BRANCHES		LEAKS.			REMARKS
	FENCE	DEPTH		FENCE	DEPTH	LOCATION	NATURE	DATE	
EAST FENCE LINE ERIE									
50									
						62'-7" 21'-6"	LEAKY BELL	6-26-98	PIPE SEEMS IN GOOD CONDITION
100	21'-11"	4'-1"							
112'-8"				21'-10"	4'-3"				
150'									
162'									
WEST FENCE LINE HURON									
202'-0"									
EAST FENCE LINE HURON									

Figure 85.—Main Record Book, page 294.

by uncovering it, was entered on the proper line according to the location. Of course, if there were to be many openings, this book record would not provide adequate space, and, therefore, it is recommended only under the conditions already described.

As will be noted, it also affords an opportunity for recording leaks.

For the new mains of the small company just considered, the field-book record described on page 289, with no transcribing, would be adequate.

Large Company

The larger the mileage of mains, the more argument there probably is for the use of one system of records for both new and old mains, although where, as is very often the case, the greatest amount of new mains is laid in one or two comparatively restricted areas on the outskirts of a growing city, no confusion would result from one system of records for these new mains and another system for all others. Also, it is quite feasible to sketch all new mains by the field-book system, and, by means of the number on the general main map, to possess an instantaneous index to any particular record. The presence of a number opposite the block for which the record was desired, would indicate that such record was made according to the field-book system, and would be found as a blueprint in the pile (or file) indicated by its number. The absence of a number would indicate that the record was on a sketch card (to be explained later on) and would be found in the proper alphabetical file.

The great value of the blueprint record lies in its presenting a continuous sketch of the main, but it does not lend itself to changing conditions, and this is one of the greatest objections to using it in large cities, where, apparently for many years to come, the installation of various underground structures, especially wire conduits with their attendant manholes, will cause many changes in main locations. To meet these conditions, the system of records used in Philadelphia, alike for new and for old mains, has proven very successful. Before describing it, a general account of the Philadelphia organization for obtaining records is advisable.

System of Records in Philadelphia

Organization

There is a Superintendent of Records, reporting directly to the Engineer of Distribution. Under him is a Chief Draftsman, in direct charge of obtaining, mapping and filing records, through the agency of street clerks and draftsmen. A street clerk usually is a graduate of a technical college or institute. Upon employ-

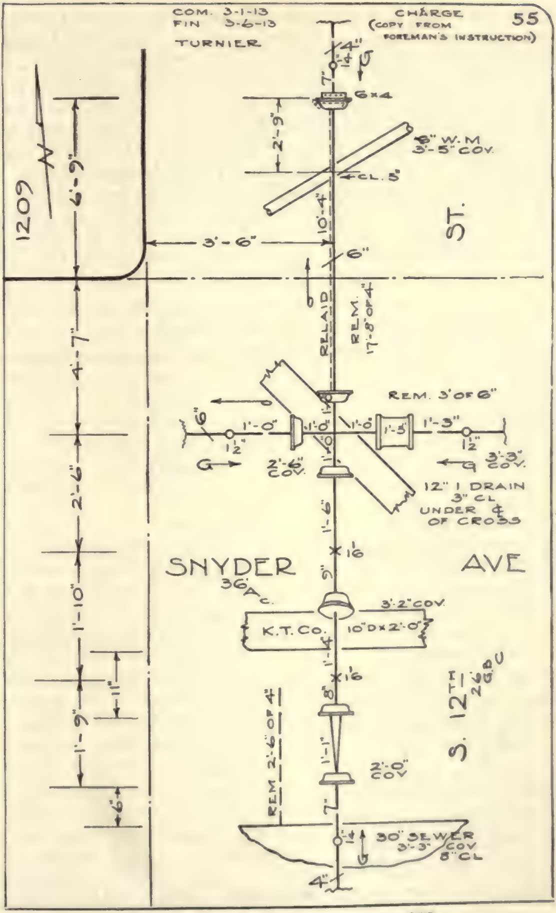

Figure 86.—Field Sketch, page 298.

ment, he is first put to work in the Records Division to familiarize himself with the system of records, one of his duties being the duplicating of records. After this inside apprenticeship, he is sent out, first, under the instruction of another street clerk, and then alone, to record the work of one or more street main gangs. In this position he is able to learn all the details of street work, and to qualify for the position of foreman in charge of main or service work. The position of street clerk, besides serving as a training school for future foremen, superintendents and managers, allows the gang foreman to devote his entire time to directing his men. When the foreman is held responsible for his main records, either the records or the work, or both, are apt to suffer.

The draftsmen, in the office, post upon the main charts the records as made by the street clerks, and also furnish various reports needed in connection with main work.

Each street clerk is provided with the following equipment:

1 45° 6-inch Angle,
1 60° 4-inch "
1 Brass Plumb Bob,
1 Note Book, $3\frac{3}{4}$ by 6-inch, 200 pages,
1 Sketch Book, $4\frac{1}{2}$ by $7\frac{1}{8}$-inch, 120 pages,
1 piece Yellow Chalk,
1 Chalking Cord,
1 Band Dater,
1 Street Directory,
1 Combination Ink and Pencil Eraser,
1 Draftsman's Soft Pencil Eraser,
1 Holder for Daily Progress Report,
6 $\frac{3}{4}$-oz. bottles Drawing Ink, black, blue, brown, green, red and yellow,
1 set Instructions to Street Clerks,
1 set Drawing Instruments,
2 Ink Pads, red and black,
1 3-H Lead Pencil,
1 Medium Lead Pencil,
1 6-ft. Extension Rule,
1 piece Soapstone,
1 set Rubber Stamps,
1 50-ft. Metallic Tape,
Clips, fasteners of various kinds, pens, blotters, printed forms and other stationery.

Field Records

A field-book record is made of all openings. A standard field sketch is shown in Figure 86. As all subsequent records depend upon the field sketch, the measurements are taken carefully and plotted clearly in every detail. Memory is not relied on in any way for information necessary for the final record. A 3-H pencil is used for this field work. Each sketch is indexed at the back of the field-book, alphabetically by its street name, and when the book is filled, it is turned in to the office, where it is dated, numbered and filed in a vault.

In making field sketches, the following points are observed in connection with measurements:

Use of Measuring Equipment

Figure 87 shows, in a general way, the application and use of the tape line, measuring rule and plumb bob. The tape line is drawn taut sufficiently to bring it to a straight line, but never is stretched. It is protected from the weather as much as possible, and if it becomes wet or soiled, it is dried before winding into the case. Every two weeks each tape is tested for length against a steel tape. In using the plumb bob, three trials are made for each measurement taken.

Measurements—How and When Taken

Curb lines are used as bases of reference wherever possible; otherwise, building or fence lines, car tracks, etc. All measurements at right angles to a main or street axis (known as ordinate measurements) are taken at each end of the block and at all angle points in the line, and are from the outside edge of the nearest curb to the centre of the main. Ordinate measurements of foreign structures always are taken with reference to the centre of the nearest gas main, and are to the nearest *edge* of rectangular structures and to the centre of circular structures. Ordinate measurements of foreign structures with reference to curbs are not taken ordinarily.

All measurements parallel with a main or a street axis (known as axial measurements) are taken from the intersection of the curb serving as a base for the ordinate measurements, with the intersection, actual or produced, of the nearest curb of the nearest intersecting street. Where streets intersect at angles other than right angles, measurements are taken as shown in Figure 88. The intersection of the curb lines of such angle

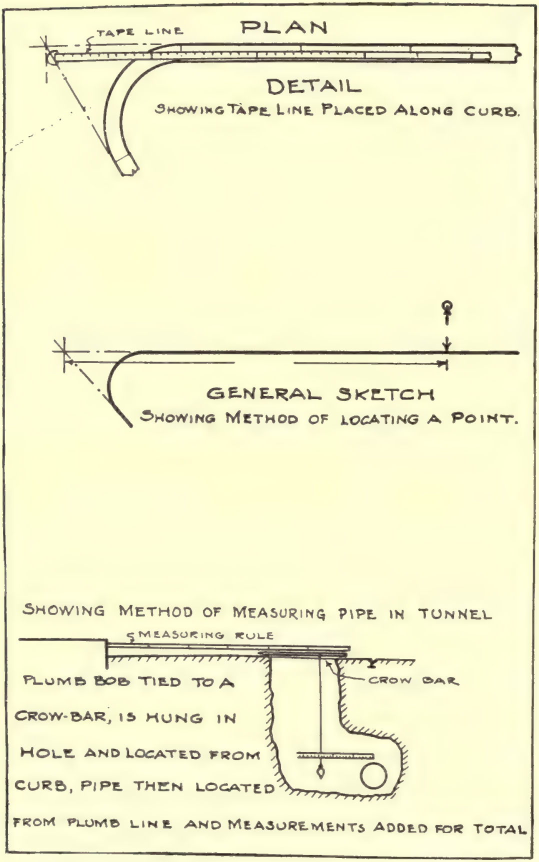

Figure 87.—Methods of Measuring, page 299.

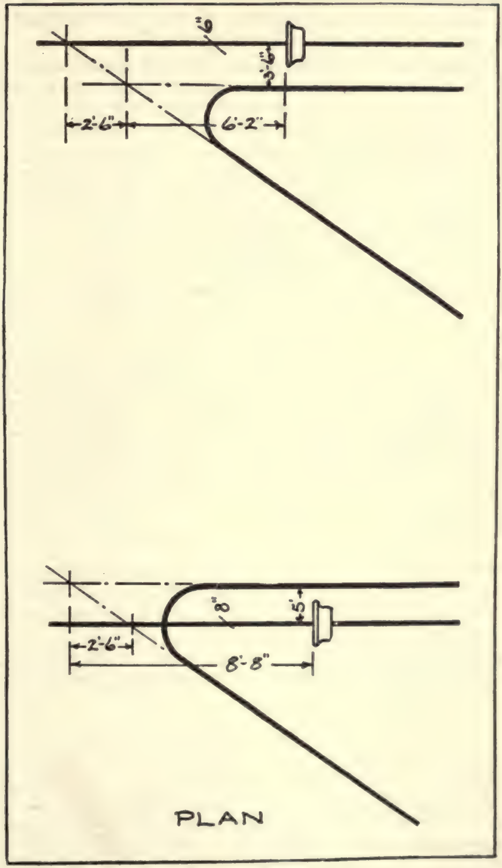

Figure 88.—Measurements at Other than Right Angles, page 299.

streets is obtained by the crossing of two lines of cord extended along, and in line with, the curbs whose intersection is desired; or, by using a chalk line, with one cord only.

All depths are taken vertically from the street surface to the top of all structures. Elevations are not shown in the field-book, unless the structures to be sketched are quite complicated, and, therefore, the ordinary plan will not show conditions clearly.

Axial measurements, in every case to the face of the nearest bell, are thus taken: On branches, from the intersection of the axes; on bends, along the axis from the angle point; and on Y's, from the intersection of the axes. Bushings are counted as being 1 inch and caps as 4 inches long.

Other details to be kept in mind when taking field records, can be stated to better advantage when describing the permanent records.

Reports to Office

Each day the street clerk makes a "progress" report, in triplicate, one for the district office, one for the Records Division, and one for himself. This report is shown in Figure 89. The form is self-explanatory, except, possibly, as to the information called for in the lines opposite "Laid or Overhauled" and "Valve, Drip, Service, etc." In these cases, the character of the work is indicated by drawing a line through all but the proper significant letter.

Permanent Records

Whenever any pipe is laid, or old pipe uncovered of which there is no satisfactory record, a permanent record, known as the sketch record and shown in Figure 91, is made from the field-book. This form, as well as Figure 86, is quadrille ruled. (Not shown by the illustrations.) Where only a few feet of old straight pipe is uncovered and no foreign structures encountered, the record is made as shown in Figure 90.

Sketch Details

In making the sketch record (Figure 91) the following details are observed: Nothing is drawn to scale, though all of the structures are shown in their true relative positions. The crossing of figures with lines, and the crowding of figures, notes and lines, are avoided carefully. The name of the street in which most of the work is done, is given at the top of the form. The north point is stamped in red in the upper left corner.

No.......To.......Inc. DATE..............................

MAIN WORK DAILY PROGRESS REPORT

DISTRICT..............................

LOCATION	........SIDE	........SIDE	........SIDE	........SIDE
INSTRUCTION NO.				
CLASSIFICATION				
SIZE MAIN	"	"	"	"
COMMENCED				
TOTAL LENGTH	'	'	'	'
DATE OF LAST REPORT OF INSTRUCTED JOB				
TOTAL OF LAST REPORT	'	'	'	'
REPORTED TO-DAY	'	'	'	'
TOTAL TO DATE	' TCH	' TCH	' TCH	' TCH
LAID OR OVERHAULED	L O SKE	L O SKE	L O SKE	L O SKE
ABANDONED TO-DAY	—OF "	—OF "	—OF "	—OF "
REMOVED TO-DAY	—OF "	—OF "	—OF "	—OF "
VALVE, DRIP, SERV. OR PRESSURE TEST. STA.	V D S P	V D S P	V D S P	V D S P
FINISHED				
FOREMAN				

LEAKS: ....

REMARKS. ....

....

REC'D R. D. .... ST. CLERK ....

FORM 4—P.G.W. MAKE 3; ORIGINAL TO R. D., KEEP 1, 1 TO DISTRICT. 15M-1-17-13

Figure 89.—Progress Report, page 302.

In general, the ruled lines of the record card are used in every feasible way, and, when possible, the centre lines are used for the mains to be sketched, which are shown by lines $\frac{1}{32}$-inch wide, according to the following scheme:

* Pipe laid in new work . .	Solid Red
Existing pipe uncovered .	Solid Black
Pipe abandoned	Solid Green
Pipe removed	Broken Green
Pipe relaid	Solid Red overlaid by Broken Black

* When the pipe used is not cast iron, its material is stated.

MAIN RECORD. .... District

Nearest house No .... St.

Charge

Nature of work .... Date ....

Size .... Cover .... Ft. .... Ins. .... Drips towards .... St.

Location of Main .... Ft. .... Ins. .... of .... Curb-line of .... St.

Location of Joint .... Ft. .... Ins. .... of .... Curb-line of .... St.

Kind of Joint .... Joint recaulked .... Yes No. .... Bell faces . ...

Foreman .... Kind of paving .... Base .... Kind of soil ....

Location of Foreign Structure .... Size .... Cover ....

Remarks ....

Rec'd B. of R. ....

Sign here ....

Form 33 P. G. W Make 2—1 to Bureau of Records—1 to District. 10M-6-20-10

Figure 90.—Main Record, page 302.

Foreign structures are indicated by lines $\frac{1}{32}$-inch wide, and the following scheme is used:

Water mains	Solid Blue
Conduits	Solid Yellow
Manholes, handholes, sewers, inlets and house drains	Solid Brown

A separate record is needed where manholes enclose mains. Where a foreign structure is being laid at the same time as a gas main, but is not actually in place when the main record is taken, its approximate location is shown by a dashed line of appropriate color. Clearances are shown in red, and give the minimum distances from a bell and also from the main itself to any foreign structure.

Existing curbs and corners are shown by a solid black line $\frac{1}{32}$-inch wide, as in Figure 92. Building and dimension lines, etc.,

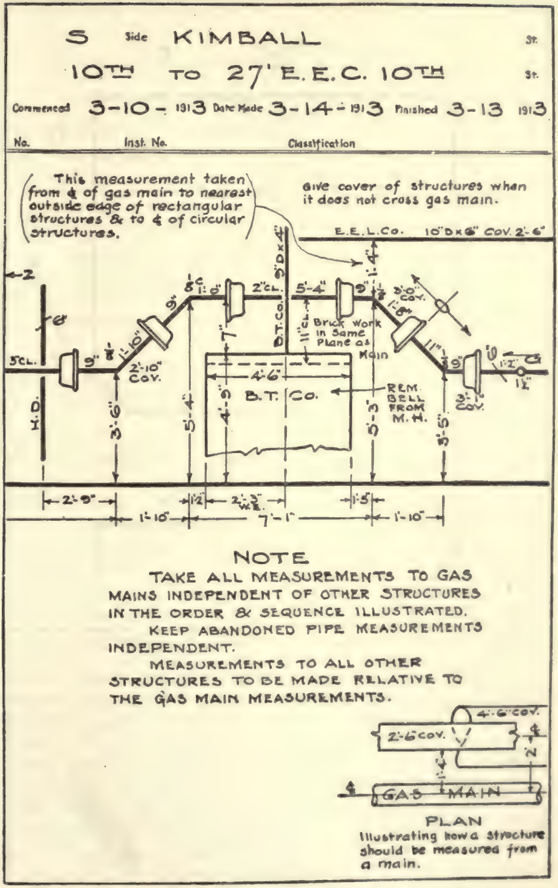

Figure 91.—Sketch Record, page 302.

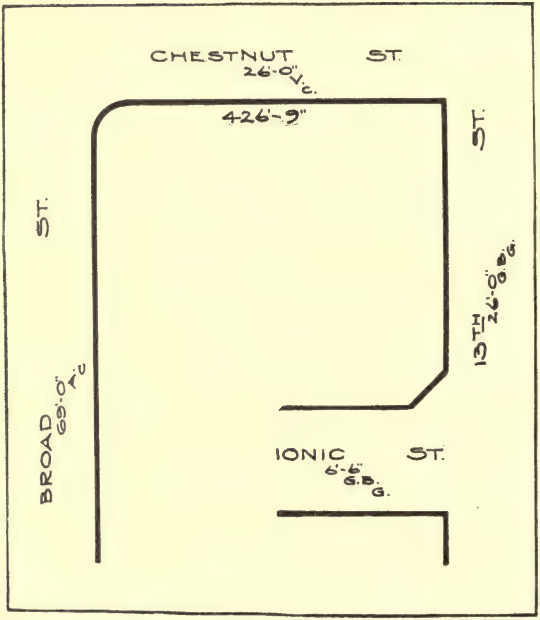

Figure 92.—Designation of Curbs and Corners, page 304.

are shown as in Figure 93. Telegraph poles, lamp posts, fire plugs and pier lines, when needed as bases for location, are shown by conventional designs. Figures giving sizes, dimensions, covers, etc., are in black above the line indicating the main, the size being shown at right angles to the main, to avoid confusion with dimension and location figures. Solid line, rubber hand-stamps designate the various forms of bells and specials. Reducers are shown solid, and tapered to indicate change in size.

Where pipe or specials are exposed only partially, this is indicated on the record. Under ordinary conditions, the street clerk does not leave in doubt the character of any special, or the relations between any intersecting mains.

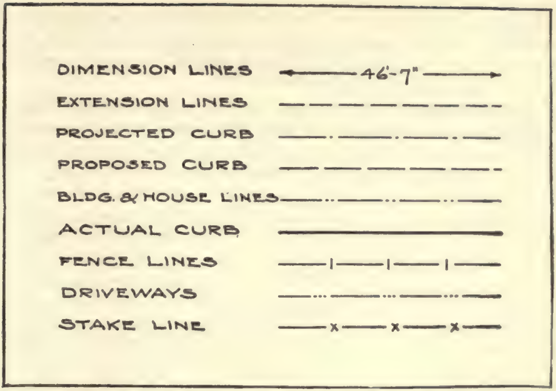

Figure 93.—Building and Dimension Lines, page 306.

Where a main is carried through the air, generally attached to the upper or under surface of a bridge, detailed information of its location is given. A detail plan of the main locations always is prepared before a new bridge is begun, and the record made by the street clerk serves as a check against this plan, if the work is carried out as originally intended, or records any difference between execution and plan. Where an existing main is overhauled, and there is no satisfactory record of its location with relation to the bridge, the street clerk secures as detailed a record as conditions allow.

Where pipe is laid above ground for temporary use only extending over several months, a special record is made.

Where mains will cross under steam railroad tracks, a plan usually is prepared in advance of the work, and the record as taken shows the relation between the tracks and the main, and serves as a check against the plan. In the case of street car tracks, a record of the tracks is not taken ordinarily where the main crosses at right angles, but always where the main is under the track for some distance, as might be the case if the main lies parallel to the track, or crosses under switches.

For each job, in addition to the sketch record made according to the foregoing rules, all the information needed for the sketch-

record card is filled out on the reverse of this card, as shown in Figure 94. The lower half is written by the street clerk, but the information on the upper half is entered by the draftsman, who uses it for the monthly report.

Of the information contained on the sketch record, only the size and general location of the main are transferred to the proper main chart, using water colors for ease in any subsequent removal, thereby preserving the surface of the chart. When these charts are on a scale no larger than 200 feet to the inch, fillets may be used to denote connections, but no other details as to specials should be indicated. With charts of 50 feet to the inch, a fairly complete record may be made, but the same large scale that makes this detailed record possible, allows such a small extent of territory to be shown on any one chart, that experience proves the smaller scale charts are preferable for ascertaining the mains in any particular region, while the sketch records must be resorted to usually for certain necessary details that even a scale of 50 feet to the inch cannot show. Therefore, the limited use of the large scale does not warrant the expense of preparing it.

The sketch records for the current month are placed in a special file until, at the end of the month, their data has been properly recorded. Then they are transferred to the permanent file, where the arrangement is alphabetical by street names, all records for the same street being filed by street number. In order to make this numerical filing possible, a hypothetical number is assigned to every record. Where the work involves only a street intersection, or an intersection and more or less work beyond the intersection in the direction in which the street is numbered, the hypothetical number assigned is the highest number belonging to the intersection on the proper side of the street. Where the work does not involve an intersection, or, if involving an intersection, extends beyond it in the opposite direction to the numbering, the number assigned is the lowest one belonging to any building or lot on the same side of the street as the work, and in front of which the work is done.

When a record embraces, in part, or entirely, the same extent of main covered by a previous record, it is filed behind the earlier record. Where mains are changed frequently, it often happens that a true idea of the exact main locations in any one block, or at any one intersection, can be obtained only by reference notes and by spreading out several sketch records made at various times, and noticing carefully how the later records

MAIN WORK SKETCH RECORD.

DISTRIBUTION DEPARTMENT

RECORDS DIVISION

REQ NO.................. AMOUNT AUTH..................

TOTAL PIPE LAID	PROGRESS REPORT	STRAIGHT PIPE ONLY	LENGTH CEM. LEAD
OF	OF	OF	
"	"	"	
"	"	"	
"	"	"	

TOTAL PIPE OVERHAULED ... "

OF ... "

" ... "

" ...

PLOTTED ON CHART		MONTHLY REPORT	MAINS LAID REPORT	NO. FT.	RECORDED	A. & R. PIPE DRAFTSMAN	BETTERED MAINS DRAFTSMAN	COMPARED FOR NOTES	HIGHWAY SUPERV'S
NO.	DATE			OLD	DATE				
	INITIALS			NEW	INITIALS				

C. I. MATERIAL USED NO.

FOREMAN.................. CAULKERS.................. NO..........

..................NO.................. NO.................. NO..........

REMOVED..................

ABANDONED IN GROUND..................

JOINTS L.....C.....S.................. PHOTO. NO.................. ALBUM NO..................

BUSINESS CLASSIFICATION......N. B.......A. B. L.......A. P.......A. R. ... I. P. ....

NATURE OF WORK..................

....

....

....

....

RECEIVED, R. D..................

.... STREET CLERK

PER.................................... DUPLICATOR.

(OVER)

Figure 94.—Sketch Record Card, page 308.

make partial changes in the earlier ones. In this way, the very state of affairs, viz., great activity in the installation of underground structures, that renders advisable the adoption of the sketch-record system, as opposed to the "blueprint" record, previously described, because of the greater ease with which small changes may be shown by means of the sketch record, sometimes produces so many sketch records relating to one block or intersection, that it becomes advisable to make what is called a "composite" record. This shows, in one record, the block or intersection as it is at the time of making the record, and until the future brings new changes, the composite record is the only one that is consulted.

CHAPTER XXVIII

BRIDGE MAINS

Reasons for Bridge Mains

Until recent years, there were no bridges in territories provided with gas mains, except where such territory was divided by a body of water. In many instances, the stream spanned was navigable, and the resultant drawbridge was of no use as a pipe support. Where the bridge was a fixed one, or where the approaches to a drawbridge extended over a long stretch of land, marshy or otherwise unfavorable for main laying, in the former case, the whole bridge, and in the latter, the approaches, have been welcomed as a means of facilitating the conveyance of gas across the water.

With the growing abolition of grade crossings of steam railroads within the limits of towns and cities, has come a great increase in bridges, of which a considerable proportion carry streets over railroads. If it is necessary, or desirable, to convey gas across the railroad at any one of these bridges, the choice lies between crossing on the bridge, or laying under the tracks. The latter alternative usually is undesirable, for several reasons, of which the two principal ones are: First, the objection of the railroad company, which desires to reduce to a minimum any work, by outside persons, that in any way affects the roadbed. If the right of way at the point of crossing is owned in fee simple, permission to cross will be given only on condition of removal on specified notice. This, of course, is not a condition that the gas company cares to accept. In every case, the railroad must be held harmless for any damage resulting from the installation or presence of the main. Second, the increased expense of installation and maintenance. As a rule, a crossing under the tracks will mean a long stretch of deep main on each side of the bridge, or else two vertical legs, each about 20 feet, either underground back of the abutment walls, or

exposed on the side of these walls. Invariably, the amount of pipe used and its depth will be greater than if the location is upon the bridge.

From what already has been said, it will be seen that the choice generally will be for the bridge crossing, whether over land obstacles, principally railroads, or over water. The disadvantages connected with a bridge main will be considered as the subject is developed.

Location of Mains

When installing a bridge main, the first point to be considered, viz., the necessary permission, is often inter-related with the second, — the location. Bridges generally are owned by the public authorities, but sometimes the railroad is joint owner. Unless the addition of extra weight is considered dangerous, permission to lay seldom is refused, but the public authorities often are very much opposed to any location where the main will be in evidence. Generally, such a prohibition means a location below the floor line, and entails extra expense in installation and in maintenance, and occasionally, where the bridge is over railroad tracks, and the head room is limited, the railroad company interposes with the provision that the proposed main do not decrease this head room. The exact point at which any prescribed location becomes so disadvantageous as to prevent the bridge main altogether, will depend entirely upon local conditions. There are, however, some general principles of location which apply universally.

Where the roadway is separated from the footway by the main girders of the bridge, a location on the top of such a girder is ideal. Next, in point of desirability, would be on the bridge floor itself, in a corner of the roadway, or (preferably) the footway. Blocks of concave top, fitting the main, should raise it 1 inch above girder, or floor, and a guard timber should protect a roadway floor main.

If there is no location available above the floor line and within the bridge lines, then alongside the bridge usually is preferable to underneath it. Often, by attaching brackets to the outside girder, the main can be placed just outside the footway railing, with the bottom of the main about the floor level. If the girder carrying the footway is deemed too light for additional weight, attachment may be made to the girder at the side of the roadway. This will bring the main under the footway.

There may be instances where the only location possible is under the main floor of the bridge. Most of the metal bridges crossing over railroads are now protected from the action of the locomotive gases, by a tight wooden sheathing over their whole bottom. Only as a very last resort should a pipe be laid between such sheathing and the bridge floor. So laid, it will, at all times, be most inaccessible for examination and painting, and be exposed to many corroding influences, and escaping gas will be both hard to detect and a great source of danger, forming, as it will, an explosive mixture inside the sheathing. Where there is no sheathing, the choice of location under the bridge will be determined by giving proper consideration to the various elements of first cost, maintenance cost, etc., that may enter into the case.

Where the location is under the bridge, provision for a future means of ready inspection should be made at the time of installation. This generally means building a platform under the pipe or leaving hangers in which boards may be readily slipped at any time.

So far, the types of bridges in mind have been those composed mainly of metal or wood. The advent of reinforced concrete has brought the concrete arch bridge into the field. With it, location above the bridge floor, or along the bridge sides, usually is prohibited, on the score of spoiling the artistic effect. Location under the bridge, in the few cases where head room was sufficient, would mean a small stretch of main exposed in an inaccessible place, with most of the pipe buried in the sides of the bridge arch. This location also presupposes the laying of the pipe while the bridge is being built, for it is not probable that permission would be given to tear apart any existing bridge. In most cases, there should be no hesitation in letting the pipe be built entirely into the bridge. The cover usually will be less than 3 feet, though something approaching this depth should be striven for. Contact with any cinder filling should be avoided. If a leak should develop at a pipe joint, there is little chance of gas finding a way out through the concrete. In fact, in a concrete bridge, it is well worth considering, where the length is great and the saving would be considerable, whether a cylindrical passage formed in the concrete would not suffice.

Provision for Mains When Designing Bridge

Except in discussing the concrete bridge, no distinction has been made between a bridge designed after ascertaining what

necessary provision should be made for pipe crossings, and one built without any reference to such crossings. No company should allow the erection of a bridge on which there is any chance of a main being needed, without at least making an attempt to have this contingency provided for.

Probably, in all large cities, as each bridge is planned, the official in charge notifies the company, and asks its needs as to size and location of pipe crossings. In any locality, in default of such notice, it is very easy to have a knowledge of all proposed bridges.

Where the main location is to be alongside, or under, the bridge, the work of laying can be cheapened greatly by suitable openings left in any masonry, and sometimes by holes drilled in, or brackets fastened to, a girder, before it is put in place. The specifications for the openings in masonry should state that the contractor will place thimbles at places designated by the plan, these thimbles to be furnished by the company. In this way, the company is bound to know where the thimbles are to be placed, and their cost is insignificant, consisting, as they usually do, of spigot pieces of cast-iron pipe of a size just large enough to permit the insertion of the bell or coupling of the pipe being laid.

Design of Mains

Material

Ordinary cast-iron pipe with lead joints probably will need frequent recaulking, due to the vibration of wooden or metal bridges, and also to temperature changes in exposed pipe. With cement joints in sizes 12-inch or under, vibration probably would not cause leaks, but temperature changes probably would, and in larger sizes, both vibration and temperature might be sources of trouble. Where cast iron is buried in a concrete bridge, it is perfectly satisfactory, but the thickness of the bridge at the arch crown may be so slight that the lesser diameter of a steel joint, as compared with a cast-iron bell, makes steel pipe preferable for the concrete bridge, as it certainly is for the wooden or the metal bridge. On the latter, the saving in space and weight afforded by steel is quite desirable. Also, in the case of under-floor locations, the fewer joints and lessened chances for leaks are important points.

Joints

Gasket

For mains 6-inch or under in size, the ordinary form of screw coupling is advisable. For 8-inch, possibly, and for 12-inch and over, certainly, a gasket joint, with plain end pipe, should be used. As compared with screw pipe, there will be a saving in first cost (always in labor and often in material) and in maintenance, for as each joint acts as an expansion joint, temperature changes bring no strain on the line, and there should be no leaks.

Screw

Where screw joints are used, an expansion joint of some kind is advisable, one for 100 feet of exposed pipe. Where there is only one expansion joint, it should be located in the centre of the line; where more than one, they should be spaced equally. Each expansion joint should be secured firmly to the bridge, in order to prevent any chance of one joint taking up all the movement. At the ends of the line, where the steel joins the cast iron (usually just before the main goes underground), it is often easy so to locate the necessary specials that any thrust or pull will be taken up by a swing joint effect.

Size

The size of the bridge main ordinarily is that of the underground main on either side. However, in cold climates, it probably is a mistake to lay smaller than 4-inch, and in many cases, smaller than 6-inch. Also, if the region supplied is a growing one, or of large extent, the bridge main should be large enough to care for future growth, especially if the location is such that replacement would be difficult.

The above applies where the main is of moderate size, say, 12-inch and under. Above 12-inch, it often might be true that the size of the main added very largely to the expense of the job. If this is the case, it often will prove good practice to make the bridge main smaller than the pipe to which it connects. To what extent this diminution in size is advisable, will depend upon the special conditions in each case, one of the important factors being the length of the bridge, and another the demand for gas during the peak load.

One way of avoiding the use of very large pipe on a bridge, when the size in itself is the objection, is by laying two or more mains. A case in mind is where a concrete arch bridge was built over a single track steam railroad, well in advance of any

development in the general neighborhood, or on the street which the bridge served. Future plans for the locality called for a 20-inch main. When the city authorities asked what provision should be made for a gas main, it soon was found that the minimum depth over the arch would not permit of larger than a 12-inch steel pipe. Neither could permission be obtained to lay alongside, or on top of, the bridge. To go under the railroad was not advisable. Therefore, two 12-inch steel pipes were laid side by side in the concrete of the bridge. They, of course, will not give the capacity of a 20-inch, but the bridge is less than 80 feet in length, and the day when the 20-inch capacity may be needed is so far ahead, that a third 12-inch pipe did not seem justified.

Except where required for real, or assumed, artistic reasons, or for protection from gases of combustion, or from severe cold, it is not advisable to enclose an exposed main, but instead, it should be painted with red lead, covered with a quiet color. A steel pipe kept well painted is bound to be less conspicuous, and takes less room, than the same pipe boxed. A cast-iron pipe, with its large bells, does not present a neat appearance. A box around the main on the floor or side of a bridge is a great collector of dirt, and corrosion will progress faster on a main covered by the ordinary box than if bare. Any covering over the pipe also renders inspection much more difficult, and an escape of gas more dangerous. However, there are cases where at least a wooden shield under the main is quite necessary, to protect it from the direct impact of the gases from locomotive or boat stacks.

As to the question of protection from cold, in the old days when a 6-inch was a large main, a time-honored rule was to make the pipe rising out of the ground and going over the bridge, at least a size larger than the underground pipe. In these days of large mains, it is safe to say that no such practice need be followed for latitudes south of New York City. In Philadelphia, the few cases of exposed mains stopped by frost have been confined to 3-inch pipe. Where the climate is severe enough to warrant the enlarging of exposed pipe, then also the question of its protection needs to be considered. Whatever form of covering is adopted, great care should be exercised to make it watertight, not only to keep the insulating efficiency high, but also to prevent corrosion. A good quality of canvas, kept well painted,

will form an excellent waterproof cover, especially when space is limited.

Inspection of Mains

All bridge mains being more liable to injury from atmospheric and other external causes, than the underground piping, should receive a periodical and careful inspection for condition, in addition to the perfunctory inspection given to them by the linewalker from time to time. This careful inspection should be yearly at least, and a good time is during the fall months, to ensure that everything will be all right for winter. The inspection usually will disclose the necessity for repainting, for minor repairs to platforms and coverings, and, in the case of cast-iron pipe, may mean a resetting of many of the joints. Where pipe is exposed to the action of combustion gases, it also is well to attempt to form an idea of how fast corrosion may be proceeding. A 12-inch cast-iron pipe, exposed under a bridge crossing many busy railroad tracks, was found on removal to have less than ¼-inch of metal left.

SECTION II
MAINTENANCE

CHAPTER XXIX
ORGANIZATION

The maintenance of a system of mains includes any necessary repairing, and involves, therefore, main laying jobs more or less extensive, depending on the condition of the existing pipe and the ideas of the management. The foreman and the general organization, described in Chapter XXII, will care also for maintenance work. The organization of the individual gangs will be given in discussing the various phases of maintenance. Here, however, should be noted that the street force of any company should be large enough always to care for the leak work of somewhat worse than the ordinary winter. This will involve, during some winter months, with both main laying and leaks at a low ebb, working with gangs composed mostly of skilled men, and, therefore, at increased cost; but, to offset this, if there are but few lay-offs during the winter, a better class of skilled laborers can be had, and there is little danger of facing a serious street leak situation with an insufficient force of trained men. The larger the city, the more important it is not to attempt the wrong kind of economy involved in too radical a winter lay-off of street men. Rather attempt, in every way, in localities where the climate is not too severe, to do a certain amount of main laying throughout the winter, on days when leak work is slack, for the increased cost, over summer conditions, of this main laying will be more than offset by the saving in maintenance expense, through using labor otherwise idle.

CHAPTER XXX

LINEWALKING

Frequency of Inspection

One detail of main maintenance becoming more and more essential in every city that has grown beyond the point where each one knows what everybody else is doing, is linewalking, viz., the periodical viewing of every street on which there is à main. Twenty-five years ago the only underground structures were sewers, gas and water mains, and their house connections. Usually the gas main and service were the last in, and there was little reason to expect any subsequent excavations. Now wire conduits are widespread, and their installation and maintenance involve a continual disturbance of the soil and often an undermining of gas structures. Were all the latter of a size in accordance with modern practice, the possibilities for harm might not be great, but as long as 2- and 3-inch mains and $\frac{3}{4}$-inch services remain general, linewalking is well worth while.

As to the frequency of such general linewalking, there is room for much difference of opinion, and from the nature of the question, no absolute rule can be laid down, but the matter must be decided from experience based on local conditions. Every other day for central congested portions of a city, twice a week for the built-up territory outside the center, and weekly for the growing fringe, would be considered good practice. Whatever the period adopted, it should be lived up to. In damage suits, the ability of the company to show a system of regular patrol, with the reasons why the frequency adopted is considered adequate, would be a good defense against a charge of negligence.

To general linewalking should be added special watchers for openings requiring more attention than can be given by the regular linewalker. Such openings are usually those made by public service companies, of which notice is given by virtue of a mutual agreement. The regular linewalker in whose territory

lies the opening, notifies his immediate superior of the need for a special watcher, and one is assigned if, on investigation, the linewalker's judgment is confirmed.

Special linewalking often is advisable during the winter months on streets with a previous bad leak history. A special linewalker, traversing daily each foot of such territory, generally will send in the first notice of any leaks, which in this way are stopped before the gas has inconvenienced any one sufficiently even for a "fake" claim. This means quite a financial saving in any locality where, because of previous leaks and damage settlements, the public and the shyster lawyers lie in wait for the smallest happening on which to base a claim, and where, if cases went to trial, there would be less chance of a successful defense if it were shown that previous cases had occurred in the same neighborhood, indicating a generally unsafe condition of the mains. It goes without saying that this does not mean a short stretch of main, for, in that case, true economy as well as good public policy would dictate a renewal, but an extensive area where, during winter weather, usually because of filled-in ground, main breaks may be expected anywhere.

In extremely cold weather, when the frost line is near to, or upon, the older and smaller mains, a special patrol of small mains, especially those serving a congested population, will be very useful in minimizing the danger of severe asphyxiation cases.

Duties of a Linewalker

A linewalker's primary duty is to report all openings and how they may affect gas structures. Without neglecting this work, he also can be on the lookout for many conditions, knowledge of which will be valuable to the company. Some of these are the beginning of house building, meters in vacant houses with open doors or windows, raised service boxes, and main or service material in positions dangerous to traffic or overlooked on completion of work. Also, as before noted, the linewalkers often will report street leaks. In view of the many uses to which linewalkers may be put, the cost of such work should not be considered as chargeable entirely to minimizing street leaks; nor the possible increase of street leaks with resulting consequences, the only disadvantage ensuing from the abolition of linewalking.

To allow for future main repairs, foreign structures, with especial reference to manholes or conduits, should not be allowed any nearer than given in the schedule following:

Size of Main	Minimum Distance
2 to 6-inch, inclusive	4 inches
8 to 12-inch, "	5 "
16 to 30-inch, "	6 "

Where a structure must be laid on top of, and parallel to, a main, a minimum clearance of 18 inches should be had.

Methods of Travel

A linewalker is more often a *rider*. A bicycle offers a very satisfactory means of conveyance under ordinary conditions. Riding thus over the principal streets, and looking each way along side streets as they slowly are passed, will enable an adequate inspection of most of the distribution system. On those streets where much traffic prevents a clear view, or where openings are numerous, actual walking may be preferable, and it will be *required* for all cases of special linewalking, already alluded to.

Reports of Inspection

Adequate and definite written reports, on a proper form, should be required of each linewalker. In this way, any misunderstanding as to his duties, or the ground to be covered, will be evident at once; a dishonest man will be obliged to falsify his report as well as neglect his work; and lastly, the file of reports can be offered as proof of an adequate system of street main inspection. The reports should be so devised that it is not necessary actually to write down every street viewed, as this would demand too much of the linewalker's time for mere clerical work. By a division of the territory into definite routes, each representing an ordinary day's work, an accurate report for each day can be made in comparatively few words.

CHAPTER XXXI

LEAK WORK

Systematic Overhauling

Details of Work

About twenty years ago, when cobble stones and other materials on a sand base comprised our only paving in large cities, and small communities had little even of this, one of the golden rules for distribution men taught the value of overhauling systematically a main system where the annual leakage per mile of main reduced to a *3-inch basis, exceeded 100,000 cubic feet. To ascertain what portions of the system had a leakage in excess of this figure, it often was the custom to shut off the meters in the section under test, cut off all but one source of supply, and then measure the gas entering from this source. With the universal use of the gas range during the months adapted to street work, it now is out of the question to shut off consumers' meters to the extent required for such a test. Also, because of the amount, — extensive already and increasing rapidly, — of asphalt and of other paving on a concrete base, it is becoming more and more true that systematic overhauling solely because of a large amount of unaccounted-for gas, is not an economical proposition. For most situations, most overhauling may be confined to specific blocks, selected because of undermining, a bad leak record, or in advance of paving. Such a program will effect, in a fairly short time, a decided improvement in the distribution system.

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*Reducing to a 3-inch basis means converting the total length of existing mains into a figure which expresses the length of 3-inch mains having the same joint perimeter. For instance, as a 6-inch main has twice the perimeter of a 3-inch, each mile of 6-inch would equal two miles on a 3-inch basis. In the same way, each mile of 2-inch would be two-thirds of a mile, of 4-inch, four-thirds, etc. The increasing use of 6-inch pipe with a leak record negligible as compared with 3- and 2-inch, has practically nullified any advantage formerly resulting from this length conversion on the basis of uniform size.

This overhauling work consists, first, in locating, and second, in repairing, the leaks found. As to the second part, the actual repairing of a main or service is covered in Chapters XXV and XXXVIII, respectively. How the leaks are located, is our concern now, and the overhauling of existing mains will be described as done on a scale warranting the employment of a special gang for several weeks. In general, the first step is to bar over the line of the main, and in that way locate the joints which need repair. The size of the gang should be determined by the work to be done and the time available for it. A competent foreman is, of course, essential, and the best conditions for thorough work obtain when the gang is small enough to ensure sufficient oversight of each man, and when the work of each can be specialized. In a gang of twelve men, there should be one or two caulkers, or joint repairers, and sufficient barrers to keep two or three bars going. As the success of the whole work depends on the thoroughness of the barring, these men should be selected with judgment, and their interest in their work not lessened by using them for digging.

Where the work is extensive enough to require more than one gang, the gangs employed should be kept preferably in the same neighborhood for ease of supervision, but each gang should be worked as a separate unit, with no interchange of men, tools or material, unless absolutely unavoidable. This preserves the individuality of each gang, locates responsibility for poor work, and promotes between the gangs a healthy rivalry tending towards efficiency and economy.

The equipment needed for an overhauling gang of twelve men would be as follows:

- 2 Leak Bars
- 2 Searching Bars
- 10 Asphalt Cutters
- 1 Soap Can and Brush
- 2 Street Leak Drills (complete with bar handles)
- 3 Caulking Hammers
- 10 Picks
- 2 Smelling Pipes
- 2 Rammers
- 10 Shovels
- 2 12-lb. Sledges
- 2 pair Bar Tongs
- 3 sets Caulking Tools (including chisels for scraping dirt from joints)
- 6 Asphalt Wedges

As the detection of leaks through barring requires the close proximity of the bar hole to the leak, usually a joint, the first step is to locate accurately the main as to line and joints. Unless existing map records are known to be correct, no barring should

be done until, by a sufficient number of openings, the line of the main and the probable location of the joints have been determined. An economical way of accomplishing this preliminary location work is to send four men ahead for this purpose while the rest of the gang are finishing at a previous location. These four men should hunt for the specials at street intersections, as not only will the specials generally determine the line of the main, but they also will reveal leaking joints and wooden plugs, left, far too often, as permanent stoppers in unused outlets.

After locating the specials at adjacent intersections, if there is reason to doubt the location of the main as a straight line between them, the main should be exposed at one or more intermediate points as may be necessary to establish its line. If the main in question is known to consist of 12-foot lengths, and the distance between the specials is approximately a multiple of 12, it will be safe to start at one special and mark off every 12 feet as the location of a bar hole. A rope about 120 feet long, tied with red tape at 12-foot intervals, is of assistance in such marking.

If the distance between the specials does not agree with an even number of full lengths, and any intermediate openings made to locate the line do not uncover joints, these openings should be extended, or new openings made, until one or more joints are located, from which bar holes can be laid out. If leaks are indicated and the joints uncovered show that any bar hole was more than two feet from the joint, a new hole should be driven. If in a stretch of 300 feet or more, no leaks are indicated and no joints have been exposed, two should be uncovered about equidistant from each other and the nearest special, in order to check the accuracy of the bar holes. Of course, all the above refers only to cases where the records are not dependable.

So far we have been concerned with getting bar holes close to pipe and joint. It also is important, especially in large cities, to guard against damage to other structures while barring. Even though the records do not indicate such structures, no barring should be done until a thorough investigation of manholes and valve boxes has shown that no structures are in the line of barring. Wooden ducts are especially liable to injury, as they offer little more resistance than hard earth.

Having detailed the precautions requisite to ensure proper location of the bar holes, we are now ready to describe how the holes are made. What will be said about barring or drilling applies also to the same operations on isolated leak work, to be

considered later. Ordinarily, there will be three men to a bar. It is important that the bar be driven as nearly perpendicularly as possible, not only for ease in driving, but also to ensure its reaching the main. When working through very hard earth, asphalt, concrete or macadam, the short leak bar (D, Figure 44, page 166) will be driven in by sledging until softer material is reached, when the searching bar (B, Figure 44) will be substituted. There may be times when the searching bar can be driven in with a churning motion, and no sledging. In Philadelphia, because of the harm that might result from puncturing other structures, the street leak drill (F, Figure 44) is substituted for the bar, at depths of over one foot, in all locations where there is danger of encountering these structures. This is the method followed: One man, with tongs, holds the bar, which is driven in one foot by sledges and then replaced by the street leak drill. This is revolved by two men, one at each end of the handle, while a third man bears down on the drill and thus increases its speed of penetration. Contact with any object becomes evident immediately, and then the drill should be removed for examination of the point to determine the nature of the obstruction and whether or not it may be damaged without concern. If not, a new hole should be started, or the drill pointed through the old hole in a slightly different direction. The drill usually is removed and cleaned once for every six inches bored.

With either bar or drill, the barrers must use care as they near the top of the main. The object, of course, is to just touch the main, preferably on the sides. This contact vouches for the proper location of the hole, and leaves little, if any, earth intervening between hole and joint. When the main is struck fairly, the sound made by tapping the bar with the sledge is unmistakable, but striking the main tangentially is not indicated by any resistance. Such contact, however, is shown by a black or rust mark on the side of the point, and, therefore, the bar should be examined carefully after each withdrawal.

The hole being made, the bar must be withdrawn, and this may be easy or hard, depending on the nature of the material penetrated, the depth, and, to a great extent, on the manner in which the bar has, by side blows, been loosened as it was driven. One of the reasons for using the street leak bar before the searching bar, is that its greater diameter makes a hole through which the searching bar and street leak drill can be driven and drawn more

easily. Ordinarily, withdrawing may be effected easily after tapping the bar sidewise with a sledge. If the soil is so hard that lifting the bar by hand is very difficult, even after this tapping, some form of puller should be used.

After the bar has been withdrawn, the chief barrer should smell the hole. For this purpose, the smelling pipe (A, Figure 44) is well adapted, conveying, as it does, any gas from the hole to a convenient distance above ground, and its small diameter concentrating, and, therefore, intensifying, a small leak.

The barrers should notify the foreman of every hole where gas is smelled. However, the foreman personally should examine every hole. In barring at intervals of 12 feet, when several successive holes smell, expense often will be saved by not digging at any hole until after several hours, or, perhaps, a day has elapsed, for in that interval, the smell, perhaps caused by only one leak, may have disappeared from most of the holes.

Overhauling work always includes an investigation of the services by barring or uncovering, precisely as for mains. This phase of overhauling, however, will be considered when treating of service maintenance.

Overhauling work also sometimes includes the abandoning of mains, whether because no longer needed, or because their replacement is demanded for reasons to be discussed later. Usually, the recovery of the abandoned pipe is determined by the relation between recovery value and expense. If the pipe remains underground, all ends should be left closed to prevent the main serving as a carrier of leaking gas. All stop boxes over drips and services should be removed.

When abandoning a main between any two points, after making both cut outs, test the abandoned stretch by water gauge, to be sure that no unknown by-pass connection still exists. Ensure that no consumer has been cut off, by lighting a burner on each piping system in every building that might have been supplied by the main.

To Avoid Breaks and Leaks

Of late, the great increase in underground structures has been the direct cause of a large number of leaks and breaks in small mains. For years, these mains, though often averaging only 2 feet 6 inches of cover, gave trouble only occasionally. As soon, however, as trenches for new structures were opened parallel to,

and lower than, these mains, sufficient settlement occurred to deprive them of support adequate to resist the frost or traffic strains generally withstood before. Therefore, it has become increasingly important not only to watch the progress of any work likely to endanger a main, but also to use good judgment in deciding when replacement by a larger main is called for. Otherwise, the succeeding winter, especially if it be a severe one, will witness many leaks and breaks in these small mains. Replacement usually is advisable only where the main is 3-inch or smaller. For the reasons given on page 65, it is true economy, in these cases, to lay a 4-inch or a 6-inch. Where the threatened main is a 4-inch, it usually may be made tight and safe by recaulking and placing proper support under each length. If, however, it has a shallow cover, it usually is better, in places where 6-inch is the standard size, to replace the 4-inch with a 6-inch, using the old 4-inch pipe in a safer location, because the labor cost of relaying the 4-inch would equal that of laying a new 6-inch, and the extra cost for material will be justified by the lessened chance for leakage. The wisdom of this substitution of 6-inch for 4-inch is especially true where the troubling excavation is quite deep. Existing mains 6-inch and larger generally require only recaulking and proper support.

The work advisable because of a bad leak record, usually concerns mains 4-inch and smaller. When the street leak record files show that in any one block a main 3-inch or smaller has broken twice, or, with only one break, is known to have less than 3 feet of cover, or to have had its support weakened through adjacent excavation, such mains should be replaced by a 4-inch or larger, according to the principles already laid down. If the leaking main is a 4-inch or larger, an overhauling usually will suffice, unless it is a 4-inch previously left in after an adjacent excavation. In this case, follow the rule for 4-inch given in the preceding paragraph. The overhauling of a leaking main ordinarily involves barring to locate the leaking joints, followed by their uncovering and repair. Where the main is in such poor condition that almost every joint is leaking, it is true economy to dispense with barring, and uncover every joint, unless the main is under expensive paving, in which case it often will pay to uncover those joints only over which the bar holes smell the strongest, and then wait several days to see whether the leaks already repaired do not free from smell some of the previous bar holes.

It sometimes will happen that the mains whose abandonment is called for by the conditions discussed under this heading, need not be replaced, because their existence is at variance with the supply of gas through the smallest extent of piping consistent with economy and good service. Often two 3-inch pipes will be found in a no-car-track street of comparatively narrow width, and should be replaced with one line of main. Again, because of past neglect, a 3-inch and a 6-inch, or larger, main will be found on the same side of a street. Here the abandonment of the 3-inch and the overhauling of the larger main are required.

Required by Paving

A proper consideration for the rights of those using the streets and, therefore, for the true interests of the company, which needs the good will of every citizen, demands that before any modern type of paving is laid, the underlying gas structures be put in such first-class condition that future disturbance of the street surface by the gas company for repair purposes will be rare. The question of service renewal under these conditions will be discussed elsewhere. The renewal of mains should follow generally the principles laid down for renewals to avoid breaks and leaks. No 2-inch main, and no 3-inch, except in small towns, when at good depth and not on important streets, should be left in service. A 4-inch main on an important thoroughfare of a large city should give way to a 6-inch or larger. The number of mains on a street should be determined as described on page 68. Unnecessary mains should be dispensed with, even to the extent of abandoning a 6- or 8-inch if the duplicate main is 12-inch or larger, and the smaller main is not required for proper gas supply during peak loads. For leaks will come, even after all precautions have been taken, and when occurring under expensive paving, the simpler the main system, the less expensive the discovery and repair.

In general, when overhauling work is being done ahead of paving, if the preliminary barring discloses many leaks, it will be wise to assume that every joint is in need of examination and repair.

Where, because of the operations of other public service companies in improving their structures prior to paving, there has been a good deal of underground disturbance, the principles laid down under "To Avoid Breaks and Leaks," apply with increased force.

Results of Overhauling

The results ensuing from following the principles advocated in this chapter – in other words, the effect of a systematic abandonment of 2- and 3-inch mains in reducing street leaks, especially in severe weather, is shown by the following data from Philadelphia. It refers to January and February, 1912, because these were two of the coldest months on record, and illustrates in a striking degree the effect of frost on small mains. Previous winters had shown the comparative immunity of the newer and larger mains, but not to the extent of the figures here given:

Record of Broken Mains

Size of Mains	Breaks			
	Old Mains		New Mains	
	Total	Per Mile	Total	Per Mile
2″	25	2.27	—	—
3″	103	.68	—	—
4″	158	.35	5	.11
6″	11	.16	14	.03
8″	5	.11	0	.00
	302		19	

If exact figures were available, a comparison of leaking joints on the above basis would tell the same story as the breaks do, and emphasize the advisability, already mentioned, of improving every opportunity to abandon pipes smaller than 4-inch.

Isolated Leaks

Investigation

Preliminary and General

Important as it is to follow a definite program of systematic overhauling of the distribution system, it is still more essential to the safety of the public and to the reputation of the company, that isolated street leak complaints invariably receive prompt and careful attention. Every year, with the increase in manholes and conduits, there is more opportunity for a gas leak to result in the formation of an explosive mixture, and also more facilities for long travel from the leak source. Thus, it not only becomes harder to find the leak, but also the chance of explosion before it is found and stopped is greater than formerly. Hence, the necessity for promptness and skill.

Street leak complaints, of course, increase as the temperature falls. They may be received by the distribution shop in a

variety of ways. First, as a complaint sent to the commercial office, and telephoned from there to the shop, if there is any reason to believe it is a street leak; second, as a complaint received directly by the shop from the public; and third, as a message from an employee as soon as he knows of such a leak. In the first and second cases, a visit by an employee (usually a complaint man) generally is required to establish the fact as to whether the leak is from the street or not, and how serious it seems to be. The general routine followed in Philadelphia, after a complaint man has left the shop to investigate what proves to be a street leak, will now be described.

Nothing will be said here as to the procedure of the complaint man after arriving at the reported location of the leak until he decides it is a street leak, as this will be described in Chapter LVII. As soon as he determines that the leak is coming from the street, he telephones to the shop, the message being received by a person of enough practical experience with street leaks to obtain certain necessary details, such as whether or not the leak in question is capable of ventilation, an idea as to general surroundings, and full information concerning any persons claiming to be affected by the odor. From this information, the shop man decides what should be the immediate course followed.

In reporting on a leak, the odor will be classed as "doubtful," thus needing a more thorough examination; "slight", or "strong." If "strong," the man reporting is instructed to stay on the job until relieved by another watchman or by a leak gang. The location of the odor, i. e., whether in the cellar of the building, at one stop box or lamp post only, etc., serves as a guide to the shop man in sending a leak gang, or to a street foreman on arriving with the gang, to determine whether immediate work is necessary after all. Any odor reported as "strong" in a cellar or at gas, drain or water boxes at curb, indicates probably a broken main or other extensive leak, and hence requires a street leak gang as soon as possible. Any "strong" odor evident at a lamp post, or at one stop box only, indicates a probable break at the bottom of the post or in the service at the cock, and whether this leak should be worked or not, is decided by a visit of the foreman.

When the odor in a building is reported as "slight," and ventilation will remove it, the leak is not watched, but in a short time is visited by the foreman to decide what immediate steps need be taken.

In cases where the odor is reported as "doubtful" in origin, the examination by a foreman will result in deciding that the odor is not gas, or else having him order a gang to the job for examination of manholes, conduits and sewers in the locality. When the report is "not gas," a further examination is made the succeeding day to check up the conditions. The odors most commonly mistaken for illuminating gas are sewer gas, creosote, oil and gasoline.

As the foreman making examinations keeps in close touch with the shop, and as the majority of the gangs actually working leaks can be reached by telephone and the gang foreman instructed to make any examination in his locality, all cases are cared for promptly.

The shop man, when he decides that a street leak should be worked at once, reaches, by telephone, the foreman of a leak gang working in the vicinity of the new leak, and tells him to attend to the latter. In this connection, it may be stated that the telephone is an invaluable aid in all leak work and should, with the automobile, be used extensively, especially in winter. The telephone will save both time and expense, while the automobile will save time where delay might result in great expense. In Philadelphia, every leak and main foreman telephones his departure from, and his arrival at, each job, and the telephone number by which he may be reached. He also notifies the shop from time to time of the progress of his work and the probable time of completion.

When telephoning a leak order, the location and size of the main probably affected is given, but in cases involving a number of structures, any information on file in regard to these structures is sketched and sent out to the foreman by a special messenger.

An adequate record should exist of all leak work. The absence of such a record might prove disastrous to a successful defense at law. For every visit to any leak location, a report should be made, showing time, conditions found and work done. If the work extends over a day, a separate report is made for each day. Also, if there is a change of foreman during the day, each foreman makes a report. These reports give a continuous history of the leak from first complaint to final repair. In the interim as filed at the shop, they show the exact conditions of all outstanding leaks.

In the above-mentioned method of investigating street leak complaints, where reference is made to the immediate course to

be pursued, it should be borne in mind that during those days of any winter when the leaks come in faster than they can be disposed of finally, the problem may be how to differentiate between street leaks, to decide in each case which leak is the more severe, and, therefore, the order in which work should be begun. Under ordinary conditions, any leak requiring barring to locate, and then digging to repair, is worked on a few hours after receipt of the complaint, but in a very severe winter many leaks may have to wait for days, and yet by the exercise of good judgment, no inconvenience result to the public, except on those cases where, because of the necessity for ventilation, rooms cannot be kept warm until the leak is stopped.

Final

It is assumed that the preliminary investigation already described has been made, and that the leak gang with necessary equipment has arrived on the spot and the foreman given the information known to the complaint man. In his work, the foreman will be guided by the consideration which experience has shown generally to be true, that certain symptoms indicate certain probable leak sources. This rule, however, has striking exceptions, for which the foreman must be on the watch, and it is impossible to formulate set rules to be followed for each variety of conditions found. At the same time, it is feasible to discriminate between leaks, as to whether there is, or is not, any odor perceptible in sewers or other underground conduits, and this division will be made in our treatment of the subject.

If the leak is reported as coming into a building, or buildings, the foreman, after receiving the report of any watchman, and dismissing him, will enter the building most seriously affected. Inquiry as to the time an odor was first apparent should at once be made of the occupant. In general, the severity of the leak is inversely proportional to its age, so that an odor of a few hours duration indicates a break, while if it has existed for several days, the cause probably is quite insignificant.

The foreman now makes an examination of the extent and point of entrance of the odor, and sees to any further ventilation that may be necessary. If more than one building is affected, each is visited in turn. While the foreman is engaged in this work, his men are making an examination of all stop boxes and vents for several houses on each side of the affected building, and of all manholes in the block. Every structure through which an

odor might reach the surface should be examined. Such are mail box posts and hollow poles.

On his return from the inside examination, the foreman decides, from all the evidence now available, the probable source of the odor. The first condition to be described will be where there is no evidence of any odor in conduits, but gas is coming through the street wall of one building. If the leak is in the roadway nearby, or in the service to the building, the gas usually will enter near the gas or water service, or else in or along the electric or telephone service, or the sewer drain. In the latter three cases, however, it may be evident in the manholes, and the method followed for its detection will be treated later on. It should be noted here, however, that where the strongest smell is from a sewer inlet, it frequently will be found that a faulty joint in the inlet, or where it connects to the sewer, has, by allowing earth to wash into the inlet or sewer, undermined a gas structure and produced the leak. Hence, barring over the settlement may soon locate the trouble.

Entrance through the housewall, at points bearing no relation to street services, frequently denotes a leak in the service of an adjoining house, or in cases where there is a cement footway, laid on a cinder base, through which the gas can travel freely, the leak may lie anywhere in the region occupied by this base. If the leak is very strong, and it is advisable at once to stop its entrance into the building, this usually may be done by digging outside the wall at the place of entrance.

The first step to locate the leak should be to drive a bar hole in the roadway at the junction of the main and the service. If there is no odor in the hole, and the service is an old one, it is probable that the service has rusted out, or broken in the footway, and one or more bar holes should be made in the footway along the service line, and an opening made if any odor is obtained. A service leak of this kind occurs most frequently at points where water may have had access to the service, viz., at the foundation walls, at the stop cock, or at the curb.

If there is an odor in the first roadway bar hole, bar further in the roadway. If no more odor is obtained, and the service is an old one, bar over it as previously described. If the service is not an old one, and there is no odor at the stop box, bar further in the roadway and be guided by the conditions found.

If no odor is found in the first roadway bar hole, but if there is an odor at the stop box only, and the service is not old, test the

barrel and ends of cock with soap suds, if this can be done without digging up. If not, or if no leaks are found, make additional bar holes in roadway. If these give an odor, the leak probably is in the main, but if they emit no odor, it will pay to dig over the service cock, as the trouble probably is somewhere in the service.

When an odor is evident at the foundation wall of one or more buildings and in more than one stop box, or in more than one box but not evident in any building, bar holes should be made over the main at the service junctions and at any cross ditches. When an odor is found in any bar holes, make sure that enough bar holes are driven to locate the leak accurately. Then dig at the point of strongest smell, remembering that if the service or any other cross ditch is near this point, it should be included in the opening. When no odor is found in the roadway bar holes, drive holes under the curb, preferably from the footway side, to learn whether gas is travelling under the curb. If this seems to be so, other things being equal, it will be advisable to open a hole over a service, in order to determine from which direction the gas is coming, and to be guided accordingly. If no odor comes from under the curb, bar holes should be made in the footway over the services.

When an odor is evident in more than one building, and not evident at any stop box, the leak probably is in a service, and bar holes should be made over them in the footway.

Considering now the condition when an odor is found in manholes, sewers, conduits, or any other open underground spaces where there is great possibility of the existence of an explosive mixture, the utmost effort should be used to prevent the spread of such a mixture, and to dissipate it by ventilation as soon as possible. To this end, the covers of all manholes should be removed, partially or entirely, each opening thus made being guarded by a watchman. He should be provided with a danger signal by day and a red lantern (B, Figure 55, page 180) by night. If the manhole is near a car track, the cars should be compelled to pass with power off, and, in addition, the rails kept wet if they are dirty and hence more liable to cause sparks. When no watchman is available, and the odor is slight, the case may be met by placing two bars across the manhole and resting the cover on them. This allows fair ventilation without creating the menace of an unguarded opening.

The direction of a leak may, at times, especially with small ducts, be told by feeling or smelling the gas as it issues from a duct into a manhole. When by an examination of any manhole, it has been determined from which duct, or set of ducts, the odor is entering, none of the pipes in this set of ducts should be sealed, but all the other ducts, entering or leaving the manhole in opposite directions, should be sealed. The nearest manholes connected with the unplugged ducts should be opened. A similar sealing of ducts in these adjacent manholes sometimes may be advisable. In this way, the probable location of the leak may be determined closely. It is bad practice to bottle up any leak, unless the odor is so slight that there is doubt as to it being illuminating gas, and, therefore, it is advisable, for awhile, to concentrate the smell. A different condition exists where gas is finding its way into a cellar through a duct. This calls for prompt sealing, followed by barring and digging, with investigation in manholes.

When the odor has been located in certain ducts, all gas structures parallel and close to the duct line should be barred over, as should also the intersection of the duct line with a gas structure or a cross ditch. If no odor is found, or if barring is impossible because of the relative position of gas main and ducts or from any other conditions, openings should be made at the locations most advisable, taking into consideration the relation of each opening to the cost of paving and number of possible leak sources. If the leak still is undiscovered, sections of the main should be bagged off, and in this way, by decrease in odor, the leak located in one particular section.

When an odor exists in one manhole only, but does not issue from the ducts, this indicates that the leak probably is close to the manhole, and all nearby gas pipes should be barred over. Often such a leak is found in or close to the manhole wall, due to a break or a pulled joint in a main built into or lying under the manhole.

Occasionally, a main will be so imbedded in the concrete of a duct that barring is impossible. It may be feasible, however, to bag off successive portions of the main, and then, by examining at each step the change in the escape of gas in the affected manholes, determine the approximate location of the leak, before digging.

General Principles and Precautions

In making the investigations that fall to the lot of a street leak gang, whose work has been only imperfectly sketched, and, from

the very character of the work, this must be so, there are certain general principles which, if borne in mind, will aid all concerned to avoid accidents and to acquire great skill in locating leaks, before making any openings. Over a period of some months, there were eight leaks found for every nine openings made. When it is considered that most of the leak work occurs in the winter, with 18 inches or more of frozen ground to get through, the gain in time and cost by minimizing openings is very apparent.

The principles referred to are as follows:

Other things being equal, gas always rises as it travels.

The examination of buildings or underground structures should not be discontinued as soon as an odor is found, but should be done as thoroughly as if no odor had been discovered.

Do not be in such haste to make an opening that the real leak is missed. In general, if the probable source of the leak is not determined otherwise within comparatively narrow limits, depressions over mains or services should be examined and barred, before other barring or any digging.

If a stop box is found obstructed, especially in cases where there is reason to suspect that if clear there would be an odor, it should be cleaned or a bar hole driven, carefully avoiding the cock.

A footway leak seldom will show in roadway bar holes, and, therefore, it generally is a safe assumption that an odor in the latter means a roadway (main) leak.

Every bar hole should pass down alongside of the pipe, as in this way an opening is made into any hollow through which gas may be passing under the main.

The location of the first bar hole should be decided from the conditions previously noted and from knowledge of the size and conditions of gas structures in the vicinity. For instance, other things equal, a pumping main is more apt to leak than a low-pressure main.

When in doubt, owing to observed conditions, as to the best location for an opening, it should be made so as to uncover the greatest number of joints, or the point of most probable breakage, such as a cross ditch.

When a leak is under asphalt, or any other pavement having a more or less air-tight foundation, enabling the formation of a reservoir of gas, a ventilating hole may be required before an accurate idea of the leak source is possible.

After uncovering a pipe, a thorough examination should be made before it is decided that no leak exists.

When working on any leak that might have obtained entrance to any building, and admission cannot be gained, it should be decided from existing conditions whether or not a policeman should be asked to force an entrance and permit an examination by the foreman. This is necessary especially if the place in question contains sleeping rooms, and the complaint has been received at night.

Temporary repairs should be made carefully to avoid a second leak complaint, previous to the permanent repair.

After one leak has been found and stopped, it should not be assumed that the trouble has been remedied completely. At least two subsequent examinations should be made to be sure that the odor has disappeared.

There are also certain precautions, which are mentioned here as peculiarly applying to leak work, but the observance of which spells safety wherever gas is encountered.

Goggles should be furnished to protect the eyes of any workman exposed to much escape of gas.

Open flames have no place in leak gang work. Electric lights, with globes guarded against breakage, should furnish the only light provided. Figure 55, page 180, shows types of available lights. Any danger from outsiders smoking, or with open lights, should be met by the aid of the police or by one or more workmen designated specially for this purpose. Usually when leaks catch fire the flames must be extinguished in order to prosecute the search. Wet bagging or clay are effective extinguishers. However, when the escape is very great, this procedure may not be advisable.

The First Aid wagon kit (C, Figure 57, page 183) should form part of the equipment of every leak gang,

and the respirator (Figure 56, page 181) always should be on hand when the leak is strong.

Except for an urgent reason, a manhole should not be entered until well aired. At least one man on top and not more than one man in the manhole should be the rule. Where the odor is strong, a rope should be placed under the arms previous to entering the manhole.

No work in which an escape of gas is probable should be done unless at least two workmen are close to the point of probable leak. Often the workmen will be exposed to much gas, especially when digging to the leaking structure. Such a man should be watched carefully, worked in short shifts, and sent away from the opening when resting. A good foreman seldom will allow a workman to be overcome.

No foreman should expose himself to gas any more than is absolutely necessary, as it is of vital importance that the man in charge of the work should maintain a clear mind. A foreman who tries to show his capacity to "eat gas" may prove a dangerous factor.

The observance of the above rules for protecting the workman against gas has resulted in no fatalities over a period of eighteen years in a company laying about forty miles of main and seventeen thousand services annually.

Repair

Joint

The repair of a leaky lead joint is effected by recaulking. If of cement, two courses are open: To cut out the entire joint to the back yarn, or only a part of it. The first course is necessary when the leaky joint is to be replaced by another cement joint, and generally preferable when cast lead is to be used. The second course, that is, the removal of only a portion of the cement, is adequate when the substituted material is lead wool.

In cutting out the cement, a cape chisel (Figure 39, page 158) is used, with a 6-pound caulking hammer. On mains 16-inch and larger two men per joint can work if time is any object.

When using lead wool, the cement is cut out to such a depth that after yarn has been driven against the cement, the space left is equal to that used for lead wool in joints of that size.

It sometimes happens that repeated caulkings of cast lead, or renewal of cement, fail to result in tight joints. Under these conditions, especially where the pressure in the main exceeds the ordinary distribution values, a leak clamp is often advisable.

The kind of packing to use with the clamp has been the subject of much study. Specially treated rubber has met with more or less success on natural gas lines, and even with artificial gas; probably in the latter case for the reason that the rubber is under great compression; only a thin edge is exposed to gas, and for a long time after installation, there may be little or no leak from the joint. Asbestos also has been used with artificial gas, but disastrously in at least one situation. In recent years, paranite, a rubber compound, has been highly recommended, and a gasket of this material is shown in A, Figure 95.

In installing a clamp, the joint, if lead, is recaulked, after which the entire joint is cleaned thoroughly with foundry brushes to prevent any dirt or rust remaining between the lead, or cement, and the packing.

The packing band is cut about $1\frac{1}{4}$ inches shorter than the circumference of the spigot, and pulled up tight. The ends, cut diagonally, are cemented with a good rubber cement, and held temporarily with a long tack, which is pulled out before the clamp is drawn up tight. Then the bull ring (that portion of the clamp which fits back of the bell) is put into place, and after it, the follower ring (that portion of the clamp which fits in front of the bell). The bolts are then entered and drawn up tight.

The work up to this point is done by two men. Then one man uses a machine wrench, tightens each nut one-half turn at a time, until the bolts all have the same tension, and the position of the face of the follower ring is in a parallel plane with the face of the bell, the distance between them being about $\frac{5}{16}$-inch.

Yarn is then stuffed in the space left between the face of the bell and the face of the follower, also between the spigot of the pipe and the inner surface of the follower ring. The clamp, which, on receipt, had received a coat of protective paint, is given an additional coating, this time of Hickenlooper mixture, before back-filling.

In Figure 95, B shows the hollowed back of a 20-inch bull ring section. C is a section of the follower ring showing the inclined surface that presses the packing against the joint face.

The equipment used for this work is distinct from that needed for any other line of main work. For this reason, and to ensure the presence of all necessary tools, it is advisable to provide a leak clamp kit, which will be complete as delivered at the place of work. The kit consists of a box, 1 foot 7 inches by $11\frac{1}{2}$ by $3\frac{3}{4}$ inches deep, made of heavy tin, and provided with clamps, handle and shoulder strap, and with a hinged top $1\frac{1}{2}$ inches deep. There are racks and clamps to hold in place the contained equipment, which is as follows:

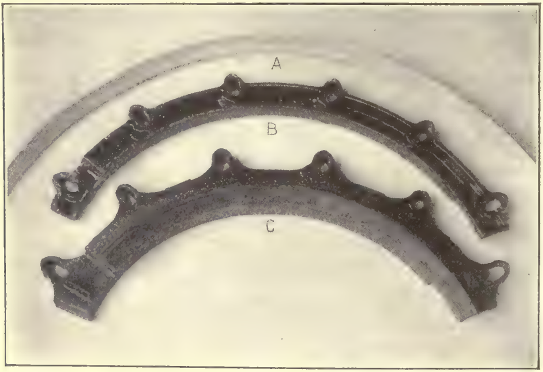


Figure 95.—Leak Clamp Sections and Packing, page 339.

1 11-inch Pinch Bar
1 box Rubber Cement
1 5-inch Cold Chisel
1 8-inch Half-Round File
1 $1\frac{1}{2}$-℔. Ball Pein Hammer
1 3-inch Knife
1 box Tacks
1 10-inch Monkey Wrench
1 9-inch S Wrench

An assortment of small blocks to centre clamps.

MAIN

The temporary repair of a broken main is accomplished by forcing soap into the crack and spreading it on the main around the crack until all escape of gas is stopped. The pipe on each side of the crack is blocked firmly to prevent any settlement

pending permanent repair, and then tallowed muslin is placed over the soap and wound and tied tightly around the pipe. In this way all escape will be prevented for days if necessary. Of course, if there are no other urgent leaks to be investigated, the permanent repair should be made as soon as the proper material is at hand, thus saving a refilling and subsequent opening over the leak.

The permanent repair usually is effected by the use of a split sleeve,—plain where no service is involved, and tapped where the break has occurred at a service hole. When the break is in a bell, it sometimes is cut off and a plain split sleeve used. Often, however, the cutting off of a cracked bell would involve a gap too long for sleeving. In this case, enough of the existing main would be cut out to allow the insertion of a new piece and solid sleeve. The details of making these permanent repairs are covered fully on pages 235 and 236.

General

Under the abnormal conditions spoken of on page 332, not only should every effort be made to increase the leak gangs, but also there should be a certain lengthening of working hours. For short periods, men may be worked 16 hours a day, and this, in conjunction with regular night gangs, will ensure unceasing search,—quite important as long as serious leaks remain unfound. In expanding the leak gangs, men from the fitting department are preferable to new employees familiar with digging, but new to leak work.

When unusual severity of weather has resulted in many days and nights of strenuous labor, those in authority should appreciate the effect of sympathy and praise in spurring men to renewed effort. Also, to night gangs and all men working past the usual meal hours, suitable food should be served.

CHAPTER XXXII

DRIP WORK

Administration

The same conditions of underground congestion in large cities, particularly the abundance of manholes, causing the use of many bends in main laying, have increased largely the number of drips. Though, because of their number and average long distance from the point of send out, the amount of condensation in each drip is apt to be slight, good practice calls for the installation of a standard drip pot where a change in grade is required. This point, as well as the question of drip pot design, has been covered on pages 58 and 80. With a large number of drip pots, an adequate system of location and condensation records is required to prevent any unnecessary drip work. In the absence of either record, the first is established easily, at least as to the known drips, by accompanying the drip man to all the drips he visits and taking proper measurements. Any drips whose existence has been forgotten, and which, therefore, are not being cared for, either are receiving no condensation or are on mains fed from two directions, and their discovery will be a matter of chance.

A condensation record must be kept for a year before it can become of the greatest value. It consists of a white card, 3 by 5 inches, headed with the location, or, preferably, the number of the drip, and filed with the drip location card. On the condensation card is recorded the date of each visit and the amount of condensation removed. It is easy to see that an inspection of such a record, in connection with the drip capacity as shown on the location card, will soon indicate how often a drip should be visited, and from this knowledge all drip work can be executed intelligently. Where proper main laying records were not kept, drip capacity may have to be largely assumed, but good judgment, aided by measuring the depth of condensation and checking against quantity removed, will furnish data far superior to none at all, and it always will be

advisable to show some figure of capacity on the drip card. Where the main is an important one, it generally will pay to excavate if this is the only way of getting the necessary information.

In the case of a main system mostly modern, the drips probably have been installed with reference to the condensation they are likely to receive. In that case, where there is little, if any, transfer of gas to outlying holders, the condensation record will show only a few drips (and those close to the point of send out) that require attention oftener than weekly.

Where, on the other hand, the system is old and many drips always have been, or have now become, inadequate to the demand on them, it will be seen that many require pumping daily or semiweekly. With either condition, whether any, or if any, how many, drips should be enlarged, is, of course, merely a question of relative economy to be figured according to the costs holding good for local conditions. It always should be borne in mind, however, in connection with drips whose overflowing would seal off important mains, that on the score of absolutely avoiding this danger, there is a strong argument for having their capacity equal two days' accumulation of the heaviest drip period.

Where all advisable increases in drip capacities have been made, the drip pumping program may be considered settled for the time. A periodical inspection, however, should be made of the condensation record to determine whether recent data indicates the advisability of reclassifying some of the drips. The execution of any program will be rendered easier by grouping the drip cards according to times of pumping, viz., daily drips, semiweekly drips, etc. Then, by lifting the proper cards, the drip man's route can be listed for him. After the first lists have been made out and until changes are required in the program, new lists can be written by copying from old ones, thus saving any card lifting. The condensation marked down for each drip by the drip man, is posted from the list to the proper condensation card.

There will be many drips which, in six months or a year, will show little or no condensation. It often will be more economical to send a man on foot or a wheel to rod these drips several days in advance of the time for their pumping. In this way will be avoided the more costly visit of the drip wagon to all those drips which show dry or nearly so. It is wise to visit each drip at least yearly, preferably in the late fall, even though no showing of

liquid is obtained, as such an inspection brings to light, cases of drip boxes resting on standpipes, paved over, or covered by dirt in unpaved streets, and also assures that no drip can, by any chance, be sealed off for more than a year.

Two types of drip wagons are described on pages 162 and 165 (Figures 42 and 43), and it is there stated that one man should suffice where the condensation was not excessive. However, wherever there is a large mileage of pumping mains transferring gas from one station to another, some drips on these mains will require daily pumping, and contain so much liquid that in the absence of any provision for power pumping, two men will be needed for the drip wagon.

CHAPTER XXXIII

ELECTROLYSIS

The author is unable to discuss, from the standpoint of personal experience, the electrolysis of mains and services. A few scattered examples in almost twenty-four years, twenty of which have been spent with a main system of over fifteen hundred miles, while disqualifying one as an electrolysis expert, show strikingly that the single-wire trolley system can exist without extensive damage to gas mains and services. The electrolysis investigations by the Bureau of Standards included measurements in Philadelphia, but it has never expressed any opinion as to the reasons for the negligible amount of current being carried by the gas structures there. The author will venture to state the conditions that, in his belief, have produced this immunity. They are: a very well bonded and large section rail; generous copper provision for return current; location of water main in centre of street, and, therefore, usually of track; location of underground conduits between car track and gas main; practice of two gas mains, each close to curb, on each car track street; use of cement joints on all new mains, now equal to 35 per cent of total mileage.

The gas engineer who is confronted continually with the problem of electrolysis, should read the publications of the Bureau of Standards and the report of the Committee on Electrolysis of the American Gas Institute, with as many of the references quoted as, on investigation, prove of value to him; should fight shy of indiscriminate bonding between gas and other structures; and, in general, beware of any method or man claiming to work wonders.

CHAPTER XXXIV

PRESSURES

General Remarks

At the outset of this book, in Chapter I, it is asserted that control of pressures should lie with the distribution rather than the manufacturing department, as the former deals directly with the public, and, therefore, is in a better position to know the pressure necessary for good service. An illustration of this could be drawn from any location at the time the inverted light was first used. The distribution department installing these lights knew that flashing back was apt to occur with any pressure below 2 inches.* Therefore, any existing pressure standard that allowed pressures to fall below 2 inches in the evening hours, in months of peak load, should be changed, unless the company was either unable or unwilling to meet the necessary expense.

Another reason is that pressure is one of the important elements of good service, and from the doctrine of concentration of responsibility, its control should be vested with the distribution department, leaving the manufacturing department responsible only for continuity of supply and uniformity of composition, two points as to which no shifting of blame is possible. Before discussing how this oversight of pressures should be maintained, it will be well to consider how to decide upon a pressure standard.

Pressure Standard

In determining a pressure standard, there are four points to be fixed, viz., maximum pressure, minimum pressure, and variations at any one meter, either practically instantaneous or within 24 hours. The usual maximum pressure, as allowed by any commission regulations, is 6 inches, and this should be considered as required only by the distribution conditions obtaining in large cities, as in those of moderate size, 5 inches, and in towns, 4.5

*All pressure measurements mentioned in this book are given in inches of water column.

inches, are maxima which it should be possible to comply with, at no undue distribution expense. The objection to maxima higher than 4.5 inches lies in the increasing difficulty experienced above that point, to meet the requirement as to variation within 24 hours, as will be seen later.

The minimum pressure should never fall below 2 inches at the burner, in order that inverted lights give satisfactory service. As the pressure must be measured in the main, allowance should be made for a permissible loss of pressure through the meter and housepiping. This may be considered as 0.5 inch, making the minimum pressure in the main, 2.5 inches. Of course, there may be special regions where, principally because of difference in level such a minimum could not be maintained, and any commission regulation requiring over 2 inches would then be a hardship. As a general proposition, however, 2.5 inches is the minimum pressure allowable over extended areas and times. Better general service will be afforded by a 3-inch minimum, as this allows over 2 inches at the burner, even with overloaded and partially obstructed piping, — conditions more or less prevalent in all places, and either unknown to or beyond remedy by the company.

The instantaneous variation of pressure refers to fluctuations caused by gas engines or instantaneous water heaters. Such a variation hardly should be the subject of commission regulation, because the cure usually is so inexpensive that if the company is responsible, it is inconceivable that the condition would not be remedied, and if the consumer is responsible by reason of not providing sufficiently large housepiping, it is not fair to mulct the company. The permissible variation should not exceed that which causes an annoying fluctuation in any light, and its amount will depend upon the normal pressure. When the latter is about 2.5 inches, any variation over 0.5 inch probably will be excessive. The remedies for such pressure fluctuations will be described when treating of the appliance whose sudden demand for gas is the cause of the trouble.

The 24-hour variation is, of course, due to the varying demands for gas at different hours. With the increasing use of gas as fuel, the greatest instantaneous demand on the main system comes on those autumn days when darkness falls and lights are needed while the evening meal is still cooking on the gas range. In the latitude of Philadelphia, this is about October, and at that time a 5-minute observation would show the greatest rate of output,

and, hence, the lowest pressures are reached. The dip is a very sharp one and seldom extends over 15 minutes. The pressure difference between the low point at this time and the maximum during the rest of the day, should not exceed 2 inches, and it will be better for the performance of most appliances if it is kept within 1 inch, and this probably will be true for most of a system living up to the other pressure requirements already described. Such a distribution system would maintain 6 and 4 inches, and 5 and 3.5 inches, or 4 and 3.5 inches at its street main governors, during its times of greatest and least sendouts respectively, and these pressures would correspond at the extremities of the system to 2 and 3 inches, so that only those consumers close to the governors would get a variation of over 1 inch.

Pressure Maintenance

Daily Operations

In order that there be accurate knowledge of the actual pressures obtaining throughout a distribution system at all times, it is essential to maintain recording gauges at an adequate number of pressure points. Preferably, the charts should extend over 24 hours only, and seven charts obtained every week, but in special locations, a 168-hour chart, or a 24-hour chart taken once or twice a week at the time of probable greatest pressure variations, may be substituted where a chart each day involves too great expense. There should be a gauge at the outlet of each street main governor, in every district shop and commercial office, and in any other company building the record from which would be representative of a section not already cared for by shop or office. Additional gauges should be placed in consumers' premises as far as may be necessary to secure records truly representative of the various conditions obtaining throughout the main system. Each gauge should be connected with the street main by a service from which no other supply is taken. In general, records should be taken from typical trunk mains, from intermediate mains and from those at the extreme ends.

All regular pressure charts should be sent to one person, and he made responsible to the distribution head for the subject of pressures. In Philadelphia, this duty devolves on the Inspector of Pressures, who always has been one of the district superintendents, as the work is not sufficient to keep one man busy, and can be added to the duties of the superintendent of a small

district without unduly burdening him. The inspector looks at each chart and is on the watch for any unusual variation. On those infrequent occasions when some occurrence at a street-main governor has caused uncalled-for fluctuations, he asks for an explanation from the governor man, and when the fluctuation is considerable, reports the case to the distribution head. This constant watchfulness is productive of great care on the part of every one having to do with pressure regulation.

As often as may be required by the change in length of daylight, or the seasonal changes in the use of gas, the inspector issues a new schedule of pressures. This is sent in the form of a typewritten letter to each man in charge of a street main governor, and its receipt must be acknowledged. All pressure changes, except minor ones applying to only one governor, call for a new schedule. This practice often involves sending a new letter to some locations where pressures remain unchanged, but it has the advantage of affording readier knowledge of the schedule governing all the governors on any given day. About seventeen schedules are issued each year, and the change in the date of issue does not vary greatly from one year to another. Therefore, with the knowledge of what governor pressures have been required in the past to obtain certain conditions throughout the distribution system, and with the current charts before him, it is not difficult for the inspector to determine the details of each schedule. In the old days, an increase at dusk and at dawn, with a later decrease as the people went to bed or to work, were the only variations required. Now, in summer the cooking load also must be cared for, and this, on Sunday, will require higher pressures than any save those at autumn dusk.

In order that the distribution head should keep in touch with the work of the inspector and with the pressures being maintained, there should pass over his desk, or that of his assistant, a complete set of charts for one day in the week.

Yearly Survey

The regular charts already spoken of would give some idea of the loss in pressure during the days and hours of maximum consumption, and those at the extremities would tell how much, if any, was the deficiency there. Their number, however, is insufficient to tell all that should be known of the loss in pressure from each governor to its extremities of supply, before deciding intelligently upon main enlargements or extensions, and they

should be supplemented by special charts, taken principally at strategic points on trunk mains, during the half hour of maximum consumption on those days when the instantaneous demand is apt to be the greatest. In Philadelphia, these charts are taken during October, and require four weeks of five days each, Saturday being the weekday omitted.

These yearly pressure locations remain unchanged except as to the few affected by new trunk mains and an extending main system. The list for each year is sent out a month in advance. This enables ample time for putting into shape all necessary equipment and inspecting each location to ensure that proper connections can be made. At all presumably permanent pressure points, a 1-inch pipe is screwed into the top of the main and brought to the street surface, terminating under a stop box marked "Gas Test." In other locations, lamp posts or drip pots are used, and care must be taken that the latter are completely dry.

In sending out the yearly list to the Inspector of Pressures and the district superintendents, a date is assigned for each set of observations. An average of ten is taken each evening, and they furnish a simultaneous record of the pressures during peak load in one section of the system. Each of these sections is visited in the same order every year, so the comparison with previous years is as close as can be obtained.

The taking of these pressures is under the supervision of the inspector, to whom, however, men for watching gauges are furnished by the district superintendent. One wagon carries the gauges, a driver, and a gauge man. Starting at 2:00 P. M., all the gauges will be set by 4:30, each gauge watchman being met at his appointed spot. At the last location the gauge man usually acts as his own watchman. The removal of the gauges begins at 7:00 P. M., and usually is in reverse order to their setting. It will be noted that this program allows about two and one-half hours for the shortest record, though not more than a half to one hour is needed. The additional time is required for days when unexpected difficulties may be encountered.

The gauges used for this work in Philadelphia are of the Bristol recording type (B, Figure 46), equipped with a water gauge (A, Figure 46) for standardizing purposes, as described on page 169. In locations where the cost of the gauges needed for anything like ten simultaneous readings would be out of the question, valuable information may be obtained by employing careful men with synchronized watches, to make readings of

water tube gauges at definite times; or, by using only three or four gauges and each day repeating one record of the previous day, a composite record may be obtained, probably as valuable as a single day's record, except where the pressure variations are great. The records, however obtained, should be sent to the distribution head and compared, by him or his assistant, with previous records to see what main work may be necessary next spring and summer to prevent any departure from the pressure standard during the succeeding autumn and winter. A direct comparison of pressures in connection with pressure changes produced by definite enlargements and extensions in the past, probably would suffice to determine the particular size of main to produce a desired result. In Philadelphia, the practice has been to convert into volume deliveries, by the use of a computer, the pressure differences along each line of main. In this way, although it is well known that the quantities obtained are not correct in any absolute sense, it is believed that effects produced by existing mains, and to be predicated of proposed mains, are shown more easily and strikingly than by using pressures only. A rough check of the calculated deliveries in the mains leading from each governor, is obtained from 5-minute readings of the actual output from each governor as measured by fall of holder on several evenings while yearly pressures are being taken.

Each year, about December 1st, tables of minimum pressures this year and for ten previous years, as obtained from the yearly pressure charts, and of assumed deliveries this year, with a discussion of any particular features of this year's records and definite recommendations for any mains thought necessary, are submitted to the Engineer of Distribution. In this way, an early decision may be had upon next year's big main work, pipe bought cheaply and specials ordered in plenty of time, so that April 1st may see the work started and September 1st see it finished, no matter what its magnitude.

Local Failures

As most distribution systems still contain 2- and 3-inch mains, cases will arise frequently where, with good pressures throughout the system as a whole, there will be a lack of gas in a limited extent of main. Of recent years, this deficiency of supply is due more and more to an increased use of gas. A case in mind is where a 3-inch main was called upon for a continually increasing number of fuel appliances until the pressure at the appliances fell

below 2 inches, and poor performances resulted. A pressure chart was obtained on the 3-inch main near the service to the appliance, and also on a 6-inch main about 200 feet away. These records showed that the drop was in the 3-inch main, and the gas flow computer indicated that the gas being used by the appliances should produce approximately the observed drop. Therefore, it was clear that a larger main was needed, and after laying a 6-inch, the trouble disappeared.

If the observed pressure had indicated the drop to be in the 3-inch main, but with a gas flow too small to account for the drop, it would follow that the main was trapped or obstructed in some other way. With a 2-inch main always, and a 3-inch main generally, except where the length is great, it is good policy, and not so very much more expensive, to lay a larger main, instead of locating and removing the obstruction. A search of this kind would be conducted by a continual bisection by openings, of the pipe remaining unexplored, and an observation in each opening of the pipe slope, with possible bagging off to get an idea of relative strength of gas flow, supplemented, if necessary, by pressure observations.

As will be inferred from what has preceded, the procedure on complaints of insufficient supply, after the trouble has been shown to be on the street side of the meter, is to determine, by pressure records, the drop through the service, and, if the service proves large enough, to find the drop through a section of main. Both for service and for main, the drop observed should be checked with that indicated by the computer for the size and length of pipe and amount of gas flow. In selecting locations for main pressures, one point generally should be as near as possible to the service junction, unless it is known that the service is large enough, in which case the pressure at the head of the service may be taken as the main pressure at the service. A second point on the main should be its junction with the nearest intersecting main, unless these two mains are the same size and there is an intersection with a larger main not much further away. Then this latter intersection is preferable as a pressure point, for it will show whether the lack of pressure is confined merely to the small main or is more widespread.

The pressure records should cover the periods of greatest demand. In many of these cases of isolated failures, it is a question of industrial use only, the small lighting load being so negligible that the records can be taken at any time when all the

appliances concerned are in use. In other cases, especially in residential districts, the record must cover the lapping of the lighting and cooking peak, and where there are automatic water heaters in use, a 24-hour record is advisable.

To obtain main pressures without digging, a drip or street lamp often may be used. Lacking these facilities, pressures at the heads of certain services supplying little or no gas are among the possibilities, but the conditions in connection with these services must be known positively before such records are considered as indicating main pressures.

It perhaps hardly is necessary to say that unless individual cases of poor supply are promptly and intelligently investigated, and quickly remedied, there will be a failure to furnish the perfect service aimed at when providing for daily pressure records at representative points and a yearly survey of the whole system under peak load.

PART V

SERVICE WORK

Under this heading is given the details of service work, the line of treatment being similar to that already followed for main work.

SECTION I

INSTALLATION

CHAPTER XXXV

ORGANIZATION

Small Towns

For services, as for mains, the organization of a working force will vary according to local conditions and to the scale of operations. In small towns, both mains and services would be looked after by one man, the general street foreman, who, at the bottom of the scale, would be a working foreman, taking his orders from the superintendent. In discussing service work, the man in charge will be referred to as the service foreman.

In the small town, or a district in the growing fringe of a large city, the work of the service foreman would comprise much detail. He would preinspect service locations, direct the movement of the service gangs, see to the ordering and delivery of material, inspect the finished work, check the report of the cart foreman, do any clerical work, and act as timekeeper.

The growing fringe of a large city has been included under the same head as a small town because, while its service work is on a larger scale, it is, in general, the repetition of the same simple operation over and over again, and does not involve the complications attendant on service laying in the congested portions of large cities. In the growing fringe, most of the services are laid in batches of fifty or more to blocks of unfinished houses on unpaved streets. Under these conditions, the service cart foreman does not need very close inspection on the part of the service foreman, for the cart foreman soon learns how to cope with the few emergencies possible. If, however, the work involves more service gangs than the service foreman is able to direct, he is given the assistance of one or more service inspectors.

The personnel of a service gang for this work would comprise the cart foreman, one driller and six or more laborers, the exact number depending upon the average length of the services laid, for the longer the service, and, to some extent, the more services laid without moving the cart, the larger the number of laborers the other two men can keep employed. Of the laborers, more than half usually will be old hands, skilled at the work. The cart foreman, besides directing the operation of his men, would, with the driller, tap the main and do all the pipe work. He should be of good intelligence, and have a thorough knowledge of service work and some understanding of main work.

Large Cities

Service work in the congested portions of large cities differs decidedly from conditions already described. It consists almost entirely in the renewal and enlargement of existing services, and often involves interference with other structures. The service foreman must consult with the employees of companies owning the structures and with the architects and builders, to determine service locations. He will, in general, decide upon the movements of his cart foremen, but will not have much time to oversee their work in detail. If there are many of them, he will need one or more inspectors, on the basis of one inspector to three or four gangs. The service foreman will have charge of, and be responsible for, the routing of the teams delivering service material, but the inspectors or the cart foreman usually will determine the nature of the material and the desired time of its delivery. The inspector, besides serving as an intermediary between the service foreman and certain cart foremen, is of especial value for the preinspection work described on page 359.

Service work in congested districts usually is slow and difficult from the presence of numerous underground structures. Dense street traffic prohibits an extensive amount of ditch openings at any one time, and renders advisable the filling of all openings at night. All these conditions militate against the economical use of a large service gang, and the force recommended would comprise the cart foreman, one skilled and two ordinary laborers. The foreman would do his own tapping, cutting and threading.

CHAPTER XXXVI

PRELIMINARY WORK AND REMOVING PAVING

Preliminary Work

Preinspection of Site

In order to execute work of any kind economically, proper planning is requisite. This is peculiarly true in regard to service work. For a new house, the service should be run before the footway paving is laid, i. e., before the house is completed. In the case of operation houses, this involves careful planning with the builder and, often, the subcontractor, to ensure that on the days set for the service work, there will be the least amount of building material in the way. When one service foreman has a district in which there are many such operations under way at one time, he must plan his work several weeks ahead, and also be ready to make quick changes, to avoid running out of work, and, as a rule, to meet the builders' desires, all without involving too long jumps of service gangs from one job to another. It easily will be seen that work of this character often entails several visits to one site before the cart foreman is ordered there. At the time of these visits, the size and location of each service may be decided, generally being the same for houses of similar design, and being governed by the principles described in Chapter XV. The cart foreman is given what directions he may need, usually when he is told to proceed to the place in question. In case of services to new isolated houses, building material is less apt to be in the way, and for these services the proper date for laying is determined easily.

Service renewals, forming the larger part of the work in congested districts, involve preinspection mainly for size and location, as the time for the work usually is the earliest date possible. In so far, however, as this work may involve the temporary discontinuance of gas supply, the exact time becomes of great importance in industrial operations, and the inspector has a chance to

use good judgment. Under every condition, the person for whom the service is being run should know when the work will be begun, so that the arrival of the service gang is never unexpected.

If the proper location for a new service may be determined definitely while the house wall is being built, the insertion of a sleeve of stove pipe, or similar material, exceeding, by 2 inches, the service diameter, is worth considering. Its value is great when, because of inferior construction, any opening in a wall is apt to affect its stability. It is an absolute necessity when the building is large and the foundation wall very thick.

Where there is no sleeve and there is reason to believe that the wall is then in bad condition, or will become so when broken into during service work, the foreman, or inspector who preinspects the site, should make a careful note of the conditions and possibly have photographs taken. These precautions, in connection with great care in making the service opening, will minimize any actual damage and prevent claims for conditions existing previous to work. Under extreme conditions, no work should be done without securing a release from the owner.

Orders for Work

To avoid confusion, no work should be assigned to a service gang except upon a written order issued to the service foreman. This order may be conveniently in the shape of a 3 by 5-inch card, one for each service, bearing the house number, with the size and location of the main if known. This card, as described on page 383, finally becomes a record of the work done.

It might be said here that the average cart foreman is not a success at clerical work, which should be attended to by the inspectors, or, in their absence, by the service foreman.

Delivery of Material

In service work to blocks of houses, all of the material is delivered directly to the site. This reduces to a minimum the load in the service cart. The pipe often is taken directly from the storage place in double team loads and unloaded at one or more locations, several days in advance of the gang. Stop boxes also may sometimes be delivered directly without involving district rehandling. The fittings and stop cocks (material too valuable to leave unguarded) are delivered to the service gang the morning the job is started.

Material for isolated jobs is either carried there by the service carts or delivered to the cart after the work has started. Where

footway or roadway traffic is dense, it is particularly objectionable to deliver material in advance of the gang's arrival.

In material delivery, the service foreman will have a splendid opportunity to exercise his brains and effect operating economies.

Nature of Equipment

The equipment recommended for a service cart, manned and moved by four men installing services 2-inch and smaller in size, is detailed below. For a larger gang, additional picks and shovels would be required. The material is in the nature of an emergency supply, to allow for delivery delays.

Equipment for Service Cart

Tools

excavating and refilling

1 Searching Bar (B, Figure 44, page 166),
1 Stone Bar (A, Figure 13, page 114),
1 Tunnelling Bar (C, Figure 13),
4 Asphalt Cutters (D, Figure 7, page 104),
4 Pick Handles,
3 Picks (page 115),
1 Driving Point (G, Figure 13),
2 Rammers (B, Figure 19, page 123),
3 Sharp Nose Shovels (page 113),
1 Tunnelling Shovel (page 113),
2 12-lb. Sledges (C, Figure 16, page 123),
2 Asphalt Wedges (A, Figure 9, page 106),
2 Frost Wedges (B, Figure 9),
2 Rock Wedges (D, Figure 9).

cast-iron mains

(Not needed on ordinary service work)

2 2-in. Rubber Bags (E, Figure 24, page 132),
3 3-in. " "
2 4-in. " "
2 6-in. " "
2 Cape Chisels (Figure 39, page 158),
3 Cold Chisels (E, Figure 26, page 136),
2 Dog Chisels and Handles (D, Figure 26),
1 Caulking Hammer,
1 8-lb. Striking Hammer (D, Figure 19),
2 Yarning Irons (Figure 40, page 159),
4 Diamond Points (A, Figure 26,
3 6-in. Stoppers (A, Figure 24,
1 set Caulking Tools (Figure 40),
1 Trowel (B, Figure 36, page 153),
2 Bursting Wedges (F & G, Figure 26).

STEEL SERVICES

1 24-in. Wall Bar (A, Figure 13),
1 Extra Long Chain,
2 12-in. Wall Chisels (B, Figure 62, page 192),
1 18-in. Wall Chisel (B, Figure 62),
1 Wood Chisel (A, Figure 62),
1 Roller Pipe Cutter, $\frac{3}{4}$-in. to 2-in. (page 138),
1 3-wheel Pipe Cutter, $\frac{3}{4}$-in. to 2-in. (page 138),
1 set Combination Drill and Tap (C, Figure 29, page 142),
1 24-in. Spirit Level (page 131),
1 Mueller Machine, complete (Figure 30, page 144),
1 set Rubber Plugs (B, Figure 24),
1 Reamer, $\frac{3}{4}$-in. to 1-in. (F, Figure 29, page 142),
1 Reamer, $1\frac{1}{4}$-in. to 2-in. (F, Figure 29),
1 set Rubber Saddles (A, Figure 32, page 147),
1 Adjustable Stock and Dies, $1\frac{1}{4}$-in. to 2-in. (page 140),
1 Solid Stock, Dies and Guides for $\frac{3}{4}$-in. to 2-in. pipe (A, Figure 27, page 139),
1 Bench Vise, (B, Figure 32),
1 14-in. Monkey Wrench
1 10-in. Trimo Wrench
1 14-in. " "
2 18-in. " "
2 24-in. " "
(page 146).

MISCELLANEOUS ACCESSORIES

1 Galvanized Iron Stationery Box,
1 Dope Brush,
1 Soap "
1 Galvanized Iron Bucket,
1 Dope Can,
1 1-qt. Machine Oil Can,
1 1-gal. Oil Can,
1 Squirt Oil Can,
1 10-in. Screw Driver,
1 File,
1 Hatchet (A, Figure 15, page 117),
1 Stop Cock Key (B, Figure 45, page 168),
1 Asphyxiation Kit (C, Figure 57, page 183),
1 Lamp Post Ladder (Figure 47, page 171),
6 Danger Lamps (F, Figure 13),
1 Safety Lamp or Electric Torch (C, Figure 55, page 180),
1 25-ft. Tape Line,
1 pr. 12-in. Gas Pliers (E, Figure 62),
1 Compass Saw (page 194),
4 Danger Signs (E, Figure 13),
1 Sponge,
1 pr. Bar Tongs,
2 Solid Wrenches for Split Sleeves.

MATERIAL

BUSHINGS

1 — $\frac{3}{4}''$ x $1\frac{1}{4}''$
1 — $2''$ x $1\frac{1}{4}''$
1 — $1\frac{1}{2}''$ x $1\frac{1}{4}''$
2 — $1\frac{1}{4}''$ x $1''$
2 — $1''$ x $\frac{3}{4}''$

ELLS

3 — $1\frac{1}{4}''$
3 — $1''$
2 — $1''$ x $\frac{3}{4}''$
2 — $1\frac{1}{2}''$ x $1''$

SOCKETS

4 — $1\frac{1}{4}''$
2 — $1''$
2 — $1\frac{1}{4}''$ x $1''$
3 — $1''$ x $\frac{3}{4}''$
2 — $\frac{3}{4}''$
2 — $1\frac{1}{2}''$
2 — $1\frac{1}{2}''$ x $\frac{3}{4}''$

CAPS

1 — $1\frac{1}{4}''$
1 — $1\frac{1}{2}''$
2 — $\frac{3}{4}''$
2 — $1''$

COCKS

2 — $1\frac{1}{4}''$

SERVICE ELLS

5 — $1\frac{1}{4}''$
3 — $1''$

45° ELLS

2 — $1\frac{1}{4}''$

LONG SCREWS

2 — $1\frac{1}{4}''$
1 — $1''$
1 — $\frac{3}{4}''$

PLUGS

2 — $2''$
2 — $1\frac{1}{2}''$
5 — $1\frac{1}{4}''$
5 — $1''$
8 — $\frac{3}{4}''$

TEES

3—$1\frac{1}{4}''$
2—$1''$ x $1\frac{1}{4}''$ x $1\frac{1}{4}''$
2—$\frac{3}{4}''$ x $1\frac{1}{4}''$ x $1\frac{1}{4}''$
4—$1\frac{1}{4}''$ x $\frac{3}{4}''$ x $1''$
1—$1\frac{1}{2}''$ x $1\frac{1}{2}''$ x $1\frac{1}{4}''$

SERVICE TEES

4—$1\frac{1}{4}''$
4—$1\frac{1}{4}''$ x $1''$ x $1\frac{1}{4}''$
3—$1''$
3—$\frac{3}{4}''$ x $1\frac{1}{4}''$ x $1\frac{1}{4}''$

NIPPLES

LENGTH	SIZE $\frac{3}{4}''$	$1''$	$1\frac{1}{4}''$	$1\frac{1}{2}''$
CLOSE	2	2	2	–
2	2	2	2	1
3	2	2	2	2
5	3	2	2	–
6	3	2	2	2
8	3	2	2	–
10	3	3	2	–
12	–	3	–	–

$\frac{1}{2}$ gallon Red Lead
1 gallon Coal Oil
1 quart Machine Oil
1 Long Service Box
$1\frac{1}{2}$ lengths $1\frac{1}{4}$-in. Service Pipe
4 cakes Soft Brown Soap
1 roll Tallowed Muslin
2 3-in. Wood Plugs
2 4-in. Wood Plugs

Cocks, especially if all brass, should be handled carefully and kept apart from other material. Unless they are in a separate container, they should, while in the service cart, be closed at both ends with screw plugs, to prevent injury to the surface of the barrel.

One of the duties of the service foreman or inspector should be to see that all tools unfitted for good, rapid or safe work, are repaired or replaced. In very cold weather, the cart foreman should examine daily such of the contents of the asphyxiation kits as are affected by freezing.

LOCATION OF EQUIPMENT

On isolated services, the cart should be placed near the trench, and on operation work, somewhere near the centre of the job.

Where service work, usually to isolated houses, is required from time to time in a settlement several miles from the ordinary spheres of activity, it will prove economical to have a service cart, fully equipped, located permanently in each such settle-

ment. Ordinarily, it may be left in a vacant lot, with small loss of tools or damage to carts. This plan will avoid long pulls by the service gangs, who, instead, will reach the cart by trolley car.

Marking Trench

The location of the service having been decided in accordance with the principles laid down on page 95, the trench is marked out by the cart foreman. Its width should vary from 16 to 18 inches. The length of opening at the main should be 4 or 5 feet, according as one or two services were being run in the same trench. The width of this main opening should follow the table given on page 223.

Removing Paving

The remarks already made under this head in describing main work on page 224 and following, apply equally well to service jobs. In cutting asphalt, it sometimes may be advisable to close shutters to protect glass from flying chips, though in general the asphalt screen should be sufficient protection. The roadway paving material should be piled inside or outside the curb as local conditions might indicate, while footway paving material should go to the curb or against the house. The general aim is either to use this material as a guard for the trenching, or to remove it from the line of traffic.

Where sod is encountered, it should be cut and removed with care and so piled that it may be replaced in its original position. Canvas covers, a convenient size being 20 by 5 feet, should be provided to protect the lawn from the excavated material. The above-mentioned precautions, combined with good tamping and sod ramming, will result in the slightest possible scar in the lawn, one that the next rain will obliterate. It also will be a good advertisement for the company at a negligible expense.

CHAPTER XXXVII

TRENCHING

General

The means described on pages 227 to 229, for the protection of the public, of the workman and of the trench, when laying mains, should be followed on service work whenever necessary. Excavation details also are similar for the two classes of work. In the absence of rock, service trenching involves no more difficult problem for the cart foreman than the obtaining of the greatest amount of work from each individual digger. As far as possible, each man should be given his own ditch, and in this way relative performance is seen more easily.

Trees are encountered more often on service than on main work, so their treatment will be dealt with here. No attachment should be made to a tree, nor material piled close around it. When the trench lies close to trees, care is necessary to avoid injuring important roots.

In opening under any gutter, either carrying water or liable to do so before the trench is refilled, the paving of the gutter should be left intact, or a trough or pipe installed to carry the water across the trench. This will prevent not only disagreeable working conditions, but possibly also a wet cellar.

With only one man on each service trench, the place to start is over the main, so that the tapping can be done and the fittings screwed in while the rest of the excavation is proceeding. The house wall is another point for early attack. When an opening (the smallest possible for the purpose) has been effected at the right height, then the trench can be bottomed in a straight line between this hole and the top of the main. Care in this bottoming is worth while if the soil is compact, for then the service pipe can rest directly on the earth, receiving continuous support and removing any fear of subsequent settlement with possible trapping, or leaking fittings due to strain.

The proper depth for services has already been treated of on page 97. The minimum grade should be 1 inch in 12 feet. The ordinary grade will be three or four times as great.

Tunnelling

In main work, tunnelling is very incidental, and there is an increasing tendency to prohibit it by ordinance. However, sometimes in main work and often in service work, tunnelling is preferable to open excavation, both on the score of economy and of paving preservation. This is true particularly of any paving on a good concrete base. Here, for service laying, the amount of excavated material is often very small, especially if driving or drilling is possible for part of the way. Therefore, refilling can be, and, with good supervision, will be, sufficiently well done to prevent the subsequent settlement of the concrete base. If the soil should be ashes or other bad fill, tunnelling usually is not practicable and is not advisable, first, because the soil will be hard to tamp back, and second, because, unless using galvanized pipe, an open trench is necessary to enable placing around the pipe, the good earth required for its long life.

Drilling or Driving

In some cases of service renewals, drilling or driving is advisable, generally to avoid disturbing some cement footway of which the house owner is proud, and is dubious of the company's success in color matching the broken blocks with the remaining paving. When the new service can take the location and depth of the old one, this method may present no difficulties whatever. The trouble is that the old service usually is too shallow at the house, and the new one must start at a lower level. Also, most of the cement footways are underlaid with ashes to service depth, so that a driven service will be surrounded by ashes, while with an open trench, this could be avoided. However, with galvanized pipe, this need not be considered.

Driving is accomplished by plugging the end of a length of pipe, or, preferably, fitting it with a driving point (G, Figure 13, page 114) and then forcing the pipe outward from the cellar, by blows from a heavy sledge on a wooden block held against the pipe. When the point has appeared in the trench outside the curb, pipe and all are withdrawn into the cellar and the service pipe shoved through the hole thus left. In ashes or other loose

soil, the opening is not apt to remain, and this may force the using of the pipe behind the point as the service pipe, assuming that it has not been hurt in the driving process.

As may be imagined, the pipe does not always drive in the direction intended, and the operation must be repeated until success results. Even if the point appears where expected, outside the curb, it does not follow necessarily that there will not be a trap in the pipe as driven. The existence of this trap can, of course, be told by pouring a measured amount of water intc the pipe and noting any lack in the issuing quantity.

Drilling is a variety of driving where a drill point is used and the pipe revolved as it advances. It is of especial application in clayey soils. Both driving and drilling require care to avoid damage to underground structures, and should not be done if such structures are known to lie across the path to be taken by the pipe.

CHAPTER XXXVIII

LAYING

General

Any services from a main extension, or service work in connection with main renewals, usually will be laid as part of the main job. This will save a second opening over the main, often enable the tap holes to be made before the main is gassed, make the supervision of all work easier for the one foreman, and, in general, keep the force of street men employed to better advantage than if the work was done at separate times.

On occasions, usually in the late fall, there may be one or more locations where, before it is possible to run the main, cement footways must be laid to avoid cold weather. If no service gangs are available, wooden ducts might be furnished the builder and properly located for future service use. The use of these ducts is more or less objectionable, because of the probability of their not being in exactly the right position, and the impossibility of filling the space between pipe and duct, thus increasing the chance of corrosion and also of a street leak entering the house. Therefore, it is advisable to make an extra effort and lay the service from the house to the street for future connection to the main by means of a long screw. Here it might be stated that unions with washer joints should never be used for underground work.

Pipe Cutting

As a general rule, for sizes 2-inch and smaller, all pipe cutting should be done on the job, by use of stock and die, with pipe held fast in the vise attached to the service cart. Power cutting to measurement, at the district shop, is profitable wherever, because of a constant distance of main from curb, and a standard stop cock location, the length from main to stop cock will be the same for each of forty or fifty houses in a block. Another

advantage of this cutting at the shop is that accumulations of short pieces of pipe may be disposed of by combining them to form one stop length.

The hindrance to power cutting of large service pipe is that until the trench is opened, it is not certain how underground obstructions may affect the work, and usually, cutting at the trench side, with a hand-power machine, is preferable to taking the measurements after excavation and sending back to the shop for the cut material.

The tools used for this work are illustrated and described on pages 138 to 148.

Connecting to Main

It was stated before, that the first opening should be made over the main. This is because service laying begins at the main and the work there requires the largest amount of time. The first operation is tapping the main. The size of opening is determined by the size of service and also, on small mains, by the size of main. Below is the Philadelphia schedule:

Schedule of Service Connections

Size of Service	Size of Main								
	30-in.	20-in.	16-inch	12-inch	8-inch	6-inch	4-inch	3-inch	2-inch
	Hole inch	Hole inch	Hole inch	Hole inch	Hole inch	Hole inch	Hole inch	Hole inch	Hole inch
1-inch	1	1	1	1	1	1	1	$1\frac{1}{2}$ S.S.	$1\frac{1}{2}$ S.S.
$1\frac{1}{4}$ "	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$	1	$1\frac{1}{2}$ S.S.	$1\frac{1}{2}$ S.S.
$1\frac{1}{2}$ "	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	2 S.S.	$1\frac{1}{2}$ S.S.	$1\frac{1}{2}$ S.S.
2 "	2	2	2	2	2	$1\frac{1}{2}$	2 S.S.	$1\frac{1}{2}$ S.S.	$1\frac{1}{2}$ S.S.
$2\frac{1}{2}$ "	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	2	3 S.S.	2 S.S.	4" x 4" T	
3 "	3	3	3	$2\frac{1}{2}$	3 S.S.	3 S.S.	4" x 4" T	4" x 4" T	
4 "	4	4	6 H.S.	4 H.S.	8" x 6" T	6" x 6" T	4" x 4" T		

$1\frac{1}{2}$" S.S. = Split Sleeve tapped with $1\frac{1}{2}$" hole
6" H.S. = " " with 6" Hub cast on

Note. — Any existing $\frac{3}{4}$-inch hole may be used for services not larger than $1\frac{1}{4}$ inches, in which case if a nipple is inserted in the main, the change from $\frac{3}{4}$-inch to service size should occur at the upper end of the nipple.

When a service sleeve is used, the hole tapped in the main may be one size smaller than the tapped hole of the sleeve.

When not to be used for services, $\frac{3}{4}$-inch hole in a 2-inch main; 1-inch hole in a 3-inch main, and $1\frac{1}{4}$-inch hole in a 4-inch main, is permissible.

Adherence to this schedule will tend to prevent mains breaking by reason of weakness at the service tap. Such breaks are not surprising when cases are known of 2-inch holes tapped in 3-inch mains. The only reason for using split sleeves tapped for a different size than the service being laid, is to decrease the variety required for stock. The reduction, in some cases, of the tap hole diameter to below that of the service, is simply taking advantage of the fact that the smaller opening will, because of the short length, deliver gas to the full capacity of the longer pipe. The use of the 4 by 4-inch tee for $2\frac{1}{2}$ and 3-inch services on 3-inch mains results from not buying any 3-inch tees. If any were on hand, recovered from old mains, they would be used. The same remark applies to the use of the 8 by 6-inch tee for a 4-inch service to an 8-inch main.

As a further insurance against weakening the main, there should be at least 9 inches between each tap hole.

The method of inserting branches and split sleeves is described on pages 238 and 241. The use of a service sleeve is shown in Figure 96.

Two types of tapping machines are illustrated and explained on pages 144 and 145. Detailed instructions for operating the machines are furnished by the makers. When working against gas, the rubber saddle (A, Figure 32, page 147) should be used.

Ordinarily, the use of a tapping machine involves an excavation to the bottom of and all around a main. On mains 20-inch and larger, this entails considerable and often particularly difficult work, which may be avoided by the use of the chain shown in Figure 31, page 145, as after excavating to the centre of the main, the chain, with attached hook, may be forced around under it.

The normal location for the tap hole is on the top of the main, as shown in Figure 97. However, any location within 90 degrees either way from this point is acceptable, if needed to afford sufficient service depth, avoid obstructions, or prevent a service drip. Figure 98 shows a connection on the side.

Any workman tapping a main or entering service fittings against gas, should never be out of sight of another workman. This is one of the most important special applications of the two-workman precaution mentioned on page 338, and to its nonobservance has been due many unnecessary fatalities. With mains supplying no consumers, and many holes to be made,

it will pay to bag off the stretch requiring tapping, and thus save the workman from any effect of escaping gas.

The hole, having been tapped, is ready for the insertion of the first fitting. This is the service tee, B, Figure 99. When the

Figure 96.—Service Sleeve on 3-inch Main, page 370.

hole is tapped in the side of the main, the outlet of the tee should be to your right as you face the main. This will cause any bearing down strain on the service to tighten the tee, and thus prevent the elbow from getting below the tee and forming a trap. When the hole is smaller than the service, the reduction is made

in the tee, entailing a minimum amount of restriction. For instance, with a $1\frac{1}{4}$-inch service from a 4-inch main, the service tee would be 1 by $1\frac{1}{4}$ by $1\frac{1}{4}$ inches. The great advantage of the

Figure 97.—Top Connection with Two Services in One Ditch, page 370.

tee over an ell for this first fitting, is the ability to stop the gas flow during service laying, by the insertion of the rubber plug (B, Figure 24, page 132), shown in dotted line in A, Figure 99. This effectively protects the workman from any gas, and should be placed in the tee before it is screwed in the main, and thus

avoid the opening of the main to the outside air that would be necessary to insert the rubber plug, after the tee, closed by an iron plug, was screwed into the main. The general advis-

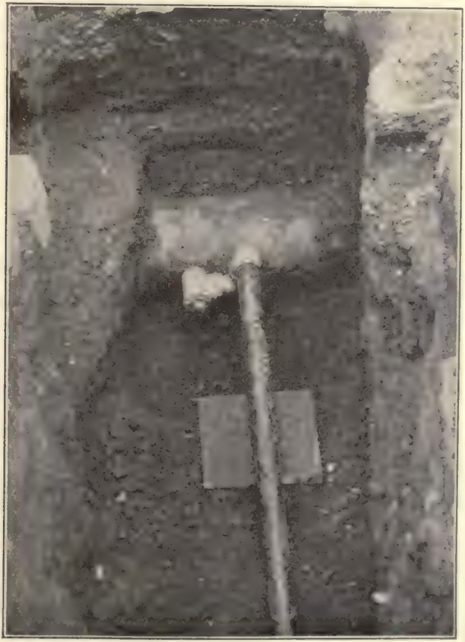


Figure 98.—Service Connection from Side of Main, page 370.

ability of avoiding such openings has been treated of on page 267. Another advantage of the tee, but one seldom needed, is the possibility of access to the service interior without cutting.

The second fitting is a service ell, C, Figure 99. The combination of the two fittings secures a swing joint at the main, thus

allowing the easy adjustment of the service pipe to any grade, without bringing strain on pipe or main, and ensuring that any future strains on the pipe will reach the main, if at all, in greatly diminished extent. The only valid objection to the substitution of this connection for the straight pipe in the side of the main, or the single ell connection, viz., the increased chance of naphtha-

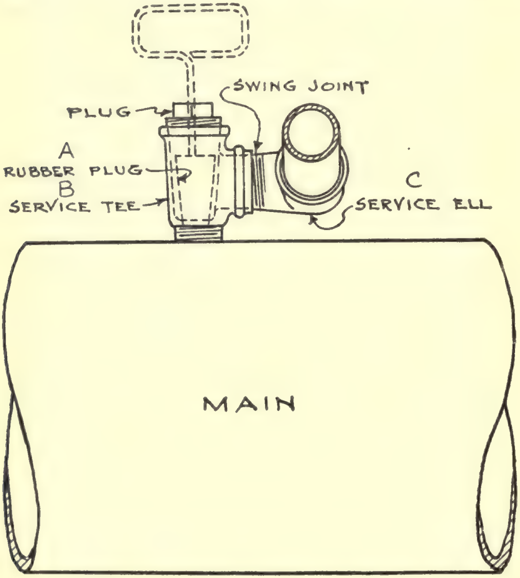


Figure 99. — Service Fittings at Main, page 371.

lene or frost stoppage at the additional turns, disappeared with the overcoming of naphthalene troubles and the laying of larger services.

Both of these fittings should be of galvanized malleable iron. Galvanizing not only adds to the length of life, but also fills up sand holes, decreasing the chance of service leaks. Also, the

fittings, as well as any service cock, should be provided with recessed shoulders long enough to cover completely any male threads joining with them and not engaging with the female threads back of the shoulders. In this way, these threads may be protected thoroughly from corrosion.

Pipe Laying

Before laying, each length should be looked through to detect any internal blister or other obstruction, and necessary cleaning effected by rodding or jarring. It should be examined also for any defective weld, though all coated pipe has been so examined prior to coating. The threads on coated pipe often are clogged by the coating or by dirt, and should be cleaned by running a die or fitting over them. The factory coupling should be backed off, reversed and then screwed tight.

Both service tee and ell being in approximately the right position, the first length of pipe is screwed into the ell. In making this, as all other joints, some jointing material is used. There are many varieties of these to suit all tastes. Possibly white lead and red lead are the favorites. Philadelphia, with coated pipe, used cement and linseed oil. This had the merits of original cheapness and small waste because of nonhardening tendency. With the adoption of galvanized pipe, red lead was substituted. Whatever "dope" is used should be applied to male threads only, and evenly spread.

After laying the stop length in the case of a main on the near side of the street, or a full length and cut piece when the main is across the way, the next step is the installation of the stop cock, if any. Stop cock design is covered on page 91, and we are interested here only in the placing of the type selected. Before any stop cock is screwed on a service, the cart foreman should see that the plug turns with just the right amount of effort. If it is too tight or too loose, it generally is wise to send it back to the shop for adjustment. The disadvantage of making these adjustments on the street is that there will be as many standards as there are cart foremen.

In screwing up the cock, the wrench should grip the end engaging the pipe. This avoids the strain that would come upon the barrel if the wrench were placed on the other end.

The house end of the service should project between 2 and 3 inches beyond the inside of the cellar wall. If after the comple-

tion of the service, no meter is to be set, the house end is capped and the stop cock left shut. At the time of meter set, a tee is screwed on the service end. Thus, by removing a plug, there is always an opening in the head of the service available for wiring or any other method of removing obstructions.

As a general rule, the service should be laid in a straight line, at right angles to the curb. Occasionally, the angle is oblique, and more rarely, being perpendicular, offsets may be required in either horizontal or vertical plane. Forty-five degree ells should

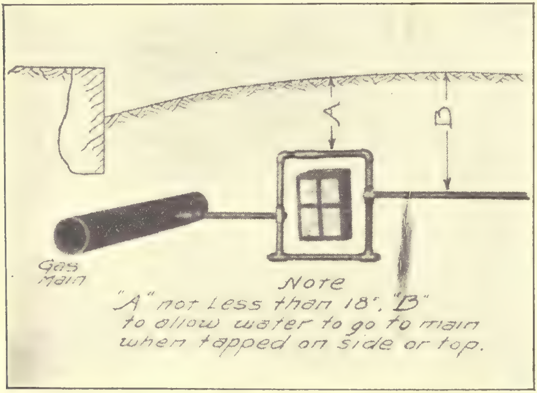


Figure 100. — Service Encircling Conduit, page 376.

be preferred for offset work, the requirement for which in a vertical plane, usually is due to the location of houses on ground well above the street level.

Very rarely, indeed, when obstructions interfere with a straight line in the vertical plane, and a service drip is inadvisable, a double line of pipe, Figure 100, may be laid around the obstruction, the lower leg draining away the condensation, and the upper leg conveying the gas.

Conduits containing cables carrying high tension current, should be given as wide a berth as possible, and when forced to

cross under or over them, the pipe should be blocked carefully to prevent future contact and possible burnout. When crossing between them, there should be sufficient clearance space to enable future withdrawal of the pipe. Earth should fill this space and also any space between the pipe and any sleeve that may protect the former from contact with the conduit.

When the pipe passes through a vault separated from, or not a part of, the premises supplied by the service, the use of an enclosing sleeve generally is advisable. Such a sleeve may serve a threefold purpose: to prevent theft of gas; to protect the service from injury, or from extreme cold. The protection of an exposed service pipe from the effects of long continued low temperature is very important in the northern part of this country, and is effected by either enlarging the exposed portion or covering it with heat insulating material, or by both methods in conjunction. Of course, in cold climates, exposed piping should be a last resort.

Figure 101 shows, in elevation, a typical service.

Blocking

To prevent joint strains and trapped pipe, the service should be supported properly. The best support is that furnished by undisturbed earth. Where this is not advisable, blocking of standard size is advocated, in place of the practice of using any handy brickbat or rock. A good size is 8 by 8 by 1 inch, and the blocks should be creosoted, because it has been found that an untreated block holds enough moisture, especially in a clayey soil, to produce a marked increase in corrosion in the pipe next the blocking. The natural blocking places are at the main, the stop cock, and under each joint. The pipe should be supported by the trench bottom or by blocking at least every six feet.

Filling and Testing

The service having been laid and supported, is ready for gas. The removal of the rubber plug has allowed gas to reach the stop cock, and the latter is now opened, so that the whole service is under gas pressure. Soap suds are then applied, with a brush, to all joints and to the cock barrel. The pipe surface is examined by smelling. The very fact that leaks in new service work are so seldom found, has a tendency to make these tests very perfunctory ones. So the service foreman should be

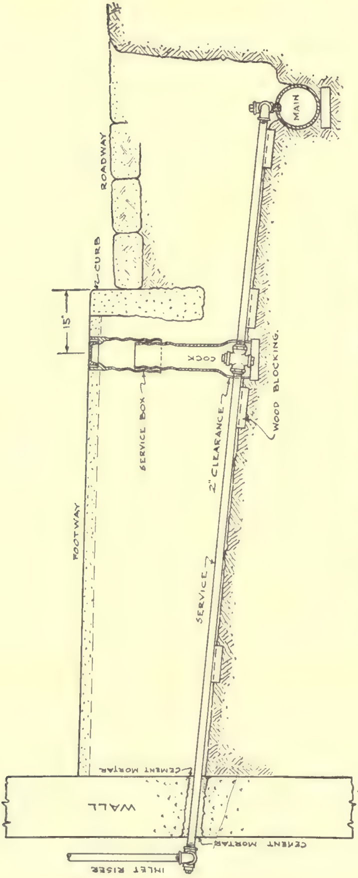


Figure 101.—Diagram of Typical Service, page 377.

on his guard in this connection to prevent any workman covering over a leak that should have been caught by the tests. After completing the tests, the curb cock is shut.

When services are laid in advance of main work, it is safe, with good workmen, to omit any test. At the time the connection to the main is made, an examination by smell should be made at all stop cocks and house ends.

If the service has been made by drilling or driving, a test with air under pressure is advisable, and for this purpose a "service tester", which combines, in one tool, a rubber plug for stopping the male outlet of the service tee, a thread and washer for making a tight joint at the top of the tee, a pressure gauge, and an attachment for a bicycle pump, has proven very useful.

Placing Stop Box

The stop box is described on page 91. In placing it over the stop cock, the flange bottom should rest firmly on earth, blocking or bricks, at a height allowing two inches clearance of box over pipe. The barrel of the box should be carefully centred over the stop cock, and earth tamped firmly around to hold it in this position. The top extension piece should be adjusted to the probable height of the footway paving.

Pipe Protection

What follows refers to the use of black material. The application of a preservative coating on the pipe is described on page 87. Because of the handling experienced from the coating shed to the trench bottom, the coating is never entirely intact on any pipe after laying. Also, the fittings are still uncoated. Therefore, the application, with a brush, of a second coat to the entire service as it lies in the trench, is well worth while. As an additional precaution, muslin is wrapped upon this second coat, and a third coat then applied. No reliable data exists as to whether the muslin protection is warranted. Probably in bad soils it would be of little avail, and in good soils it is not required.

CHAPTER XXXIX

REFILLING AND REPAVING TRENCH

Refilling

In general, the remarks made under this same head in describing main work, on pages 278 to 287 inclusive, apply equally to services, and need not be repeated here. Unless the expense is prohibitory, good soil should be placed next to any pipe not galvanized, in a layer at least 6 inches thick.

The majority of service trenches for new houses are refilled loosely, as sufficient time usually elapses before paving or sodding to admit of proper settlement. For services to occupied houses (usually renewal work), tamping—and of the most thorough kind—generally is required, for paving or sod must be replaced immediately, and puddling is not desirable on account of the danger of water getting into the house, and also of making the trench too soft for immediate topping with paving or grass.

The hole through which the service entered the house wall should be closed in carefully, and the wall on both inside and outside face, cemented thoroughly around the opening. Any joint or space between two lengths of curbing, and showing in the trench, also should be made water-tight by cementing. These are necessary precautions to prevent a water leak through a service opening — annoying to the consumer and reflecting on the company. (See page 283.)

As service work involves the footway as well as the roadway, the resultant muss is more under the consumer's feet than is true of main work. Therefore, all the more reason to clean up thoroughly and promptly when completed houses are involved. Any material that cannot be taken away by the service gang should be piled in the least objectionable place, pending its final removal.

Repaving

What has been written for main work should be read for its application to service work. Ordinarily, the service gang will do

no permanent repaving, either leaving the trench mounded over and guarded by danger signals, or flush with the neighboring surface, with or without temporary repaving. Of roadway paving, belgian block or cobble lend themselves to temporary repaving, with the consequent avoidance of lamping expense and street obstruction pending permanent repaving. Of footway paving, no temporary restoration is usually made. The paving material should be piled neatly; if footway, close to the house, and if roadway, at the curb line or house line, as indicated by local conditions.

CHAPTER XL

RECORDING

Reasons for Records

Service records are not as essential as main records. For valuation purposes, if each house supplied is charged with a service of average size, most of the service investment will be accounted for. Also, in the absence of a record, a service is more easily found than a main, as its location at the house is always known. When there is a stop cock surmounted by a stop box, this in itself is sufficient location record, except in unpaved streets or footways and under a snow or ice cover. The above is not meant as an argument against service records, but merely as a statement of the relative importance of main and service records.

In Philadelphia, service records are used:

(1) When digging for a leak in front of a closed house, with the stop box hidden under paving or dirt.
(2) To locate a hidden stop box.
(3) To obtain data concerning old mains.
(4) To obtain age of service.
(5) To decide responsibility for bad paving conditions.
(6) To explain and locate partly completed services.
(7) To prevent service duplication in cases of building alteration.
(8) To furnish information about service valves.
(9) To furnish information as to gas supply either to inquirers or when a "new set" order is received.
(10) To determine the advisability of service renewal in advance of repaving.

System of Records

Location

A card suitable for filing has proven to be the most economical location record. The 3 by 5-inch form used in Philadelphia

is shown in Figure 102. It is in duplicate, the two cards being fastened along the bottom edge and separated when the record is complete, one card going to the district and the other to the

SERVICE RECORD

NO. .... ST.
NAME .... 191....
SUPPLIES ....
NATURE OF WORK ....
SIZE .... IN. LENGTH .... FT. .... INS. SIZE TAP .... IN.
.... FT. .... INS. .... OF .... LINE OF LOT
JOINT, SWING .... IN. SLEEVE
COCK AT CURB .... KIND OF BOX .... U. G. I. COATING
SIZE OF MAIN .... IN. COVER .... FT .... INS.
.... FT. .... INS. .... OF .... CURB LINE
DRIPS TOWARDS .... ST.
INSTALLED BY ....
FORM 59-P.G.W. 60M-12-18-14

ORDER ISSUED, DATE ....
REASON ....
MAIN, SIZE .... COVER .... FT. .... INS.
.... FT. .... INS. .... OF .... CURB
DID METER PASS ORIFICE TEST? .... TESTED .... MIN.
GAVE HOUSEPIPES .... MINUTES' TEST ....
WHAT RESULT? ....
REMARKS ....

Figure 102.—Service Record Card, page 383.

Records Division. The back of the original is blank, while that of the duplicate contains printed matter, as shown. The first four lines of the back, and the address on the front of the original card, is filled in before it is handed to the general service foreman. This serves as his order to lay the service.

Of the other information on the front of the card, the "Name" as a rule is not necessary, and is omitted. The "Size" and "Length" are important, but the "Size Tap" hardly is necessary, as the few cases where it differs from the service are regulated by rule and can be told by the information as to service sleeve.

The location with reference to lot line and the cock location are needed only with covered up or no stop box. The main data are not required when the main is one for which complete records exist, but, of course, it is very valuable for old mains whose whereabouts are known principally from these service records.

It will be seen from the above that in the case of most new services, much of the information shown on the card is unnecessary. However, it requires but little time to write for the few services installed by a gang each day, and an attempt to omit certain items in certain cases, might, with the class of man who often fills out these records, lead to a confusion which would involve omissions where not desired.

When the service is completed, the card is filed geographically.

Age

Very few companies know the age of their old services. Those laid in recent years have the date of installation on the location record, but if this is the only age record, much work would be involved in listing services laid in the same year. Such knowledge may be of much importance if in any city the critical age of many services falls within the limits of several years. In that case, there will be many service failures in the winters of the critical period, involving some more or less serious asphyxiations and service repairs under very expensive conditions. With a proper age record, it would be a simple matter to investigate each summer a number of services of the critical age, and be guided by the conditions found in determining upon necessary renewals.

The age record, as shown in Figure 103, also gives necessary information for obtaining unit costs, and, therefore, the expense of the record is slight compared with its value. The illustration shows how, with a few entries, a record of age, length and class is obtained.

Cost

The record of material used for a service may be kept in a variety of ways. When there is a good reason for knowing the exact cost of each service, the back of the service card may be

SUMMARY OF SERVICES

District.

ADDRESS	Date Laid	Size	LENGTH NEW		LENGTH RENEWED		RENEWED U. G. I.		REMARKS
			Feet	Ins.	Feet	Ins.	Feet	Ins.	

Figure 103. — Age Record of Services, page 384.

used for this purpose. In general, the obtainment of individual service costs is expensive and not warranted, as a unit cost per foot of each class of service suffices not only for estimate purposes, but also as an incentive to economical operation. Such unit cost is obtained cheaply by using as a divisor the length totals of the age record book, and as a dividend, the labor and material costs charged to the proper service account. The labor is reported on payroll vouchers, and the material on material sheets, one of which, for convenience, may include many services. As the proportion of large and small services laid by various districts or foremen is about the same, no subdivision of cost by size is required for incentive reasons. For estimate purposes, however, it is necessary to keep the cost of a few individual services of various sizes, in order to get a per foot cost for each size. Further cost details are given in Chapter IX.

SECTION II

MAINTENANCE

CHAPTER XLI

ORGANIZATION AND INSPECTION

Organization

As service maintenance involves principally the replacing of existing services, the same force is used for maintenance as for new installations, and the remarks in Chapter XXXV apply to maintenance also. Equally applicable to service work are the arguments given in Chapter XXIX for maintaining a competent force of street men during winter weather.

Inspection

General

The "linewalking" described in Chapter XXX covers services as well as mains, especially with reference to openings. There are, however, certain features connected with curb or stop cocks that render advisable especial inspection of services provided with these cocks.

Stop Boxes

If all stop boxes could be located in a cement footway properly laid, there would be little or no reason for stop-box inspection, as the boxes would not be raised by frost or lowered by settlement. In the box used in Philadelphia, shown in A, Figure 5, page 84, settlement is made difficult because of the broad base flanges, and another hazard incident to stop boxes, etc.,—the accidental displacing of the cover,—is *entirely* removed by having the latter heavy and deeply set into the box.

In many localities, however, the footways are unpaved, or of brick or flag, and all these conditions contribute to boxes becoming high or low with reference to surrounding surfaces. Therefore, a more or less systematic inspection of stop boxes is advisable perhaps once a year, preferably in the spring.

If besides reporting conditions not remedied, the inspector is expected to correct slight discrepancies in box or paving height, he should be provided with a pick, shovel, stone bar, trowel and a little cement. Any work not done by the inspector should be completed by a man with more extensive equipment. If the inspection includes work inside the box, it concerns the stop cock or the valve, which are spoken of further along.

As a final result of this box inspection, the box and surrounding paving should be at the same level, the lid and any inscription thereon in good condition, and the box accessible, not being covered by paving, by material, or in any other manner.

Stop Cocks

The design of stop cocks and the precautions necessary to ensure proper manufacturing and assembling are discussed on page 91. With the best of care it still will be advisable to inspect any 2-inch stop cocks annually, to be sure that the plugs are not stuck fast in the barrels. This inspection could, if desired, embrace that of the stop boxes, as before explained. The equipment for the combined inspection should include also a 3-pound caulking hammer, a heavy stop key (B, Figure 45, page 168), a stop box lifter, a stop box cleaner (A, Figure 45), a 14-inch pipe wrench, and a large flat file. To this list may be added two 18-inch lengths of pipe large enough to fit over the stop-key handles.

In making the inspection, the man should remove the box lid, using the hammer to loosen it if stuck, and should file off any roughness or projection on the lid or the box that was the cause of the sticking. He should next remove the dirt and obstructions from the box, and placing the key on the stop head, should, if the cock is open, move it the fraction of a turn and then move it back again. This movement should be so small as to preclude the possibility of the gas supply being interfered with. If the cock is closed, the inspector should enter the building and make sure that no gas can escape inside, before turning the cock open. If he cannot get in, it should not be turned open. If the cock moves easily, it is assumed to be in good condition; if hard to

move, the gas, if on, should be shut off at the meter, and the stop turned around and around, using the pipe handles and the wrench for extra leverage, either until it is sufficiently eased, or until it is certain that the fault cannot be remedied by this means. If the latter, orders should be given to dig up and grease, or to renew.

Valves

The equipment for and the detail of the inspection of service valves are almost exactly similar to that for service cocks, just described. The inspector should examine carefully the valve stem for corrosion, and the stem head for tightness and strength of fit. With valves, a few full turns toward shut, and back again, should be made, as this will not interfere with the gas supply. It is important to know in which direction the valve turns to open, and not to open a shut valve unless it is known that no gas will escape inside the building.

Exposed Pipe

Where service pipe is exposed in places likely to be infrequently or never visited, such as manholes not belonging to the company, or ducts, or vaults, a periodical inspection of conditions should be made at least once a year. This inspection should consist of an examination of the pipe and, wherever necessary, a cleaning and protecting by painting or covering.

CHAPTER XLII

RENEWAL

Systematic Overhauling

Details of Work

The description given in Chapter XXXI of the conditions under which systematic overhauling of mains is called for, applies equally well to services. Usually, the investigation of mains and services would proceed at the same time. If the service has a stop cock and box, its location is determined easily, and bar holes may be made accordingly. Otherwise, it will be necessary to enter each house and thus ascertain the location of the house end, and also whether the service seems to lie at right angles to the main. Ordinarily, a leaky service under grass can be detected by dead or dying patches; but the use of a "pipe locator" is recommended where there are many long services, with no location records, and a knowledge of their exact line is desired; and, in general, to remedy the inconvenience caused by incomplete or inaccurate records of underground structures, and to reduce the expense necessary to correct these records by digging test holes. This instrument consists of a coil frame, Figure 104, a receiver, A, Figure 105, and a battery box and vibrator, B, Figure 105. Through suitable connecting wires, a current from a number of dry cells in box B, is sent through the main or service whose exact location through its entire length is desired. Two receivers like A, one without the headgear, are connected to the coil frame, Figure 104. The operator keeps a receiver at each ear, and, holding the coil frame in a horizontal plane, walks around and "explores" the ground near the location of the supposed pipe. The current which is going into the pipe so affects the coil that a distinct buzz is heard in the receivers, until the middle bar of the coil frame is parallel to, and vertically above, the pipe through which the current is being sent, when the buzz ceases. Each point so found is staked, and the search

continued until enough points are located to locate definitely the structure under investigation. No true indication of the depth is given, but the horizontal location is learned, within a very few inches at most. The results thus obtained may be incorrect if some other underground structure is in contact with the one being investigated, because the current is thus led astray, and

Figure 104. — Coil Frame of Pipe Locator, page 390.

so a water main may be followed instead of a gas main. Accuracy is impossible also when there are many external noises, which would confuse the operator's clear hearing. The instrument will not locate dead ends.

The repairing of a service after the leak has been found, generally involves renewing in whole or in part. A renewed service

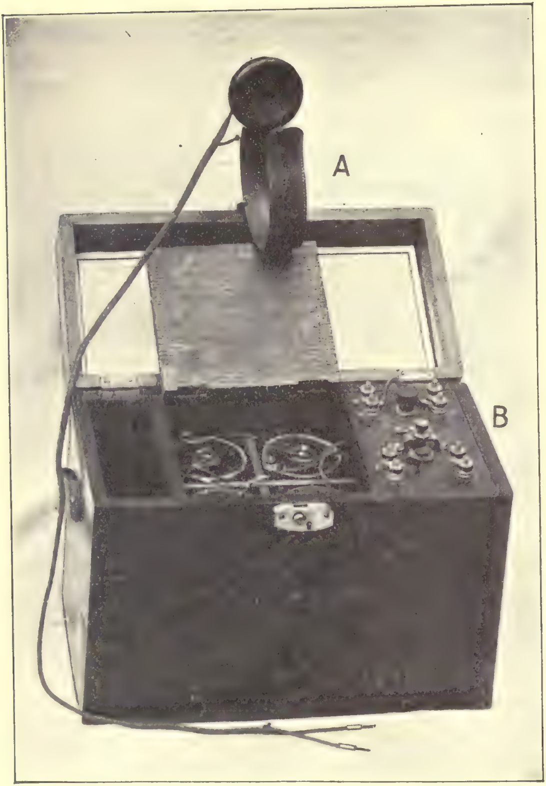


Figure 105.—Pipe Locator: A, Receiver, page 390; B, Vibrator and Battery Box, page 390.

should be located preferably in the same line as the old one. This, in a footway of flagstone or of cement which need not be broken, enables the use of the previous stop box hole, the standard location being disregarded in this case.

Renewal generally has to do with an existing gas supply. If the work must be done on account of leak or paving, but the house is shut up, the new service should be run from the main to inside the curb. The old service should be cut off at the main, and a notice left under the front door explaining why the gas supply was discontinued, and that as soon as entry may be had to the house, the new service will be completed and gas again turned on.

An abandoned service should be cut off at the main unless the latter also is to be abandoned. Unless abandonment is forced by the condition just described, any connected meter should be removed previously. Any pipe end remaining underground should be cemented up. The house end should be cut off flush with the inside of the cellar wall and filled with cement.

To Avoid Breaks and Leaks

While extensive main renewal may be brought about because of excavations undermining small pipe, as described on page 327, such excavations seldom are the determining cause for service renewal. This would be the case only where the service concerned was of sufficient size, and corrosion had progressed to such a point that, while the pipe was strong enough for use under undisturbed soil conditions, it was not considered able to resist the strains that might come upon it by reason of ground settlement, even though supported as well as possible.

Required by Paving

One of the major causes for service renewal is the paving, or repaving, of footways and roadways. It is a duty that every company owes to itself and to the community to see that no service of insufficient size or poor condition is allowed to be covered by a cement footway or an expensive roadway paving. In renewing these services, the governing principles should be those laid down in Chapter XV.

Renewal for Age

In general, the renewal of a service primarily for age is brought about by a leak complaint, resulting in the discovery that the pipe is corroded badly, and should be renewed. As,

however, such leaks are very apt to occur in winter, due to the frost strain proving too much for the weakened pipe, it always is possible, in a large city, if every service is allowed to remain in use until it so fails, to have an overwhelming number of such service failures in a severe winter. This is increasingly apt to be true in the future in locations where extensive repaving has caused many service renewals over a few years. In connection with such renewals, main work probably has been done, so that when the next repaving occurs, nothing will be needed in the way of main repairs. It easily may happen that there will be no reason for either main or service repairs until such a time as the services begin to fail through corrosion. Under such conditions, the advisability of renewing services before failure, under favorable conditions, as explained on page 384, is beyond question.

Renewal for Size

Another frequent reason for service renewal has been insufficient size, which often means a combination of a small service and a partial, or complete, stoppage impossible to blow out. The material within the pipe is the result of improper manufacturing methods in the past. The installation of proper size services soon will reduce renewals for size to locations where greatly increased use of gas has occurred.

Results of Overhauling

To show the effect of a systematic renewal of services in reducing service leaks, the record in Philadelphia, for January and February, 1912, is offered. While it is true that these two months were abnormally cold, the records for ordinary winters show that the relative performance of the old services was worse than in 1912.

Record of Service Leaks

New Services		Old Services	
Total	Per Thousand Services	Total	Per Thousand Services
226	0.8	445	5.3

Isolated Leaks

Investigation

The method of investigating isolated leaks in services is described on pages 329 to 338, inclusive.

Repair

Temporary repairs are made as follows: When a fitting is broken at the main, clean around the break and stuff the crack with soap, clear a small space around the main at the fitting, then wrap the soaped fitting and secure it to the main by using a strip of tallowed muslin about three inches wide. Use twine to fasten the wrapping. When a fitting or pipe is split, clean around it and work soap carefully into the crack, then wrap with tallowed muslin and secure with twine. When pipe is broken at thread, follow a similar procedure, and, in addition, block the pipe on each side of the break to prevent any movement. When a service is rusted out so badly that it cannot be successfully soaped, the best temporary repair demands the insertion of a piece of new pipe, making the joints with the old service with soap and muslin. When, for any reason, this cannot be done, tallowed muslin should first be wrapped over the rust holes, then a thick coating of soap applied, and then another wrapping made of muslin and twine. Such a repair should be followed by quick permanent renewal of the pipe.

The permanent repairing of a service rusted out, or in doubtful condition, at several points along its length, should consist of a complete renewal of the service. If the defect occurs at one point only, the rest of the pipe being good, or if the defect has been caused by external violence, such as a stop box "riding," or by a digging tool, the repair should be made by cutting out the defective section and inserting a new piece of pipe. A leaking thread should be releaded or replaced as necessary. A leaking valve or stop cock should be replaced, the gas flow being stopped by bags or plugs, on services 2½ inches or larger.

General

Occasions sometimes arise when it is desired to put again into use a previously abandoned service. Unless this service is exposed throughout its entire length, or it is known to be of recent installation, a pressure test should be made prior to reuse.

PART VI

STREET LIGHTING

Under this heading will be considered the installation and maintenance of lamp services (as distinguished from house services), risers and posts, also a method of recording posts and some remarks on the inspection necessary to insure a high standard of burner efficiency. Nothing is said about the types of lights in use, their proper spacing, or any other conditions affecting street illumination, as these things have to do with gas utilization, and not its distribution.

CHAPTER XLIII

INSTALLATION

Service

As service matters in general are covered on pages 86 to 100 and 357 to 395, inclusive, this chapter is limited to the conditions peculiar to lamp services only.

Figure 106 shows a standard method of service and post installation. At times a riser from the main will be advisable to prevent, in the case of a deep main on the same side of the street as the lamp, too great a slope of service. The lamp end of the service will have to be bent slightly in order that the upper face of the reducing ell be in a horizontal plane.

Riser

The lamp riser shown in Figure 106 consists of enough $\frac{3}{4}$-inch pipe to place the lamp cock at a proper height, a $1\frac{1}{2}$ by $\frac{3}{4}$-inch reducing socket, and its especial feature, the anti-freezer, or bottom section of $1\frac{1}{2}$-inch pipe, 2 feet 6 inches long. During extreme weather, there is much condensation from the gas as it comes from the relatively warm ground temperature to the air temperature of the riser top, and before this liquid can flow back into the main, it changes to frost. Experience has shown, in thousands of cases, that with the ordinary northern winter, a riser entirely of $\frac{3}{4}$-inch pipe will be closed completely one or more times during cold weather, while with the $1\frac{1}{2}$-inch base sufficient room is provided for an accumulation of frost adequate to tide over the usual cold spell. Therefore, the lamp with an anti-freezer seldom has a stopped riser.

The riser should be assembled at the shop.

Post

Figure 107 illustrates a post used since 1900. Its design was influenced by a previous record kept of broken posts to ascertain

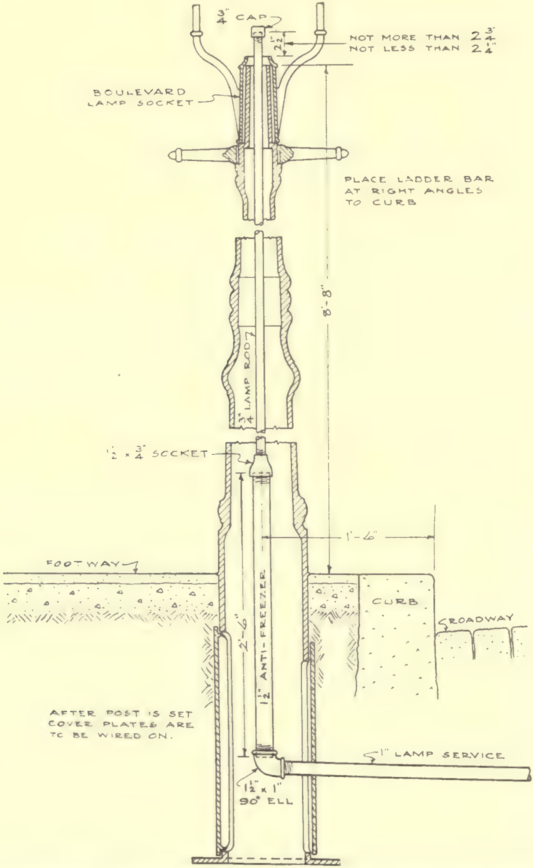


Figure 106.—Street Lamp Post Section with Riser and Service.
page 399.

Figure 107.—Street Lamp Post, page 399.

where existing designs failed. Especial attention is called to the width of the bottom flange, as shown in Figure 106. Previous designs had very inadequate flanges, rendering the post quite liable to settlement. With a wide flange and a well rammed refill, the post, if resting on firm ground, should stay as put.

Another feature of the post are the two elliptical openings, whose dimensions are the smallest compatible with proper access to the post interior and which are adequately closed by the cover plates.

Post Erection

In erecting a lamp post, two men only are needed. The riser is inserted into the post before the latter is placed over the service end. Then, with a wrench put through the large opening, the riser is screwed into the $1\frac{1}{2}$ by 1-inch reducing ell on the service. One cover plate closes the large opening, and two, if necessary, the small opening, meeting at the service pipe and making a close junction by reason of the semicircular notches which fit around the pipe. The three plates are wired tightly to the post. Of course, care is exercised to place the post on a firm and level foundation, so that it will be, and stay, vertical in all directions.

In most cities the post is set at a standard distance inside the curb, sufficient to prevent damage from roadway traffic.

Records

It is advisable to assign a number to every post in service. Whether, when a post is removed, its number should be considered as available for another post, will depend somewhat on the numbering scheme adopted, but, in general, numbers should be used over again. Where the lamps are divided into inspection districts, each with its lighting routes, it may be an advantage to number accordingly. Thus 3-A-101 would be the one hundred and first lamp in the third lighting route of the A district. Where there are many changes in lamp locations, with consequent re-routing of the lighters' work, this composite numbering may not be as satisfactory as a single number.

In Philadelphia, as orders for lamp erection are received by the Street Lighting Division, they are entered in a book. The order to do the work is made out in triplicate, two copies being sent to the proper district, on the card shown in Figure 108. This order includes authority to run any necessary service.

The duplicate stays in the district shop until the original card comes back from the street, when it is forwarded to the Store Room containing a list of material used. The triplicate is kept at the Street Lighting Division until the return of the original on the completion of the work. Then the book record is checked

ORDER NUMBER

STREET LAMP ERECTION ORDER

________ SIDE ________ ST.

________ FEET ________ LINE OF ________ ST.

IN FRONT OF ________

SERVICE INSTALLED BY ________ DATE ________

POST ERECTED BY ________ DATE ________

POST PAINTED BY ________ DATE ________

LAMP PLACED BY ________ DATE ________

CHARGE POST WORK TO ________ ACCOUNT

CHARGE SERVICE WORK TO ________ ACCOUNT

Figure 108.—Street Lamp Erection Order, page 402.

against the card, the location is posted on a map, proper notice to light the lamp is given, and any other records made that may be called for by local conditions.

The routine by which a post is renewed is similar to the process of erection. In both cases, the completed work orders are so filed at the Street Lighting Division as to be available instantly at any subsequent time.

CHAPTER XLIV

MAINTENANCE

Candlepower

Where the lamps are operating under candlepower requirements very close to their best performance, a high-class organization will be necessary to obtain satisfactory results. This will require, in addition to the usual inspectors or supervisors of lighters, one or more special men to make frequent general inspections, both with and without photometric tests. However, by the use of what is known as the trombone photometer, the ordinary inspectors can be taught how to keep their sections in such a high standard of efficiency that the special inspectors will seldom find much to correct.

Physical Equipment

Burner replacements will be made because of candlepower requirements or damaged condition. Such damaged condition and injury to all other lamp and post equipment usually is reported by the lighter, who sees each post twice a day. Some replacements he makes himself, and the remainder are reported to the Street Lighting Division, by postal or telephone, for transmission to the proper district, following the same routine as for lamp erection, and using the telephone where a quick repair is needed. The district makes, without order from the Lighting Division, any repairs brought to its attention through other sources.

In a situation of over 20,000 lamps, each inspector worked six days a week. Each night he inspected every lamp in one lighter's section for condition of burners and cleanliness of glassware. This was followed by an early morning trip through two sections to check time of extinguishing. A chief inspector made general inspections five nights in each week. Reports from all these inspections were entered in such a way that it easily was seen how often every lamp and every section was being inspected.

PART VII

METER WORK

Under this heading will be given a history and description of the consumer's dry meter; the considerations controlling, and the methods of, meter installation; the organization of and the rules for meter fitters; the tests required for proper meter maintenance; and the records necessary for a life history of each meter, including the gas passed in each location in which it is used.

SECTION I

METERS

CHAPTER XLV

HISTORY

Before the invention of a measuring device, illuminating gas was sold to the public by contract. The quantity and price were estimated according to the hours of consumption, through burners of a stated kind. Inspectors were employed to visit the houses of the consumers to see that all lights were extinguished at a certain time, and, in case of failure to put out the lights, the inspectors were authorized to shut off the gas supply from the street. As might be expected, this contract system was fruitful of complaints and disagreements, and resulted in great loss to the gas companies, due to unscrupulous and dishonest consumers. Under these conditions, the early gas companies were not successful financially, and an accurate and inexpensive device for measuring the gas became a matter of vital importance. The necessity for a meter being apparent from the earliest days of the introduction of coal gas as an illuminant, we naturally find that the efforts of the most skilled men in the science were turned strongly in that direction.

The first meter was made in England by Samuel Clegg in 1815, twenty-three years after the first use of coal gas. It was of the wet type, consisting of a measuring wheel, or drum, divided into a number of compartments and revolving on a horizontal axle, being driven by the pressure of the gas. This drum was enclosed in a stationary case, and both case and drum were filled with water to a specified height. This meter was improved by John Malam in 1817. Samuel Crossley still further improved it in 1820, greatly reducing the loss in gas pressure by so placing the partitions of the measuring drums that

they would enter and leave the water at an angle with its surface, and by providing means for the water easily to enter and escape from the revolving compartments. To these three men the gratitude of the gas engineers of all times should be accorded, for the reason that through their efforts, the meter was developed as a practical registering machine, enabling the growth of the gas business from a condition of almost complete failure to its present enormous development.

The first dry meter was invented by John Malam in 1820, but it was never actually used. It consisted of six diaphragms, radiating from a hollow shaft inside of a tin case, and controlled by a valve resembling the rotary valve sometimes used in meters of the present day. The action of this meter was due to gravity, and not to the pressure of the gas. Not till 1833 was the subject again given attention, in which year a one-diaphragm meter was invented by Mr. Bogardus. He also invented a two-diaphragm meter in 1836, but after expending large sums in the attempt to perfect its action, he laid it aside.

A practical dry meter, which was accurate in registration and regular in its action, was invented by Messrs. Croll and Richards in 1844, and put into general use. This meter is the most simple in design of any of the meters invented, and is, in principle, the two-diaphragm, double slide-valve meter largely employed at the present time. Changes in the construction of the various parts of this meter have been attempted from time to time, but, as a general rule, have been discarded after more or less lengthy trials. The essential construction of this original dry gas meter has remained unchanged, and meters of this type are in active operation in every civilized country in the world.

Meters of the wet type were first manufactured in this country in Baltimore in 1832 and in New York City and Philadelphia about 1835, but most of the meters needed were imported free of duty from England prior to 1864. Then a prohibitive import duty of 40 per cent was imposed, to the great advantage of the home manufacturer and, finally, to the user, as the cost of meters prior to 1864 was about twice the cost at the present time.

The prepayment meter was first made and used in England about 1889. In 1894, the first prepayment meter in this country was made, in New York City. It was constructed along the same lines as the Parkinson meter then made in England, the exception being that the mechanism was so changed that a 5-cent piece, instead of the English penny, could be used in buying gas.

Shortly after the introduction of this meter, it was changed to enable the use of a 25-cent piece, but did not prove a success. In 1896, a meter was made in Philadelphia having the cut-off valve and cut-off mechanism placed in the gallery of the meter, and the coin cylinder, or slot part, and cash box placed on the inlet side of the meter. The coin-driven mechanism was designed for the purchase of gas by means of a 25-cent piece. This meter was a decided improvement over the other types in use, and quickly met with the approval of the gas companies. A number of different styles of prepayment mechanisms were introduced by different makers about this time, some being duplicates of English mechanisms, others being improved or original mechanisms.

CHAPTER XLVI

DESIGN

Characteristics of Various Types

Ordinary Meter

Both wet and dry gas meters are used as consumers' meters, but the advantages of the latter type, in the two-diaphragm form, have been so proven that it has become the predominant type. In a general way, the relative advantages of the two types are as follows: A wet meter will measure, with great accuracy, the gas delivered through it, and as there are no slide valves to get out of order, or diaphragms to become hard or porous, it does not require the periodical testing which is necessary to ensure the correct registration of a dry meter. On the other hand, it requires frequent visits to maintain a sufficient quantity of water and a proper meter level. The great advantages of the dry meter are freedom from danger of freezing, reduced danger of collection of water in any trapped places in the housepiping, owing to the absence of water in the meter, reduced first cost, greater ease in setting and in handling, and fewer maintenance visits.

Prepayment Meter

Prepayment meters are employed extensively, though a few of the larger companies have given them up after a more or less extended trial. The principal objections are: the extra first cost; the extra stock required; the increased expense of testing and maintenance, and of changing from one type to another to suit the consumer; the numerous cases of robbed and damaged meters where the consumer usually is required to make good the loss sustained, and, therefore, becomes disgruntled; and the danger incurred from the escape of gas through unlighted burners when, by means of a coin, the valve is opened after it has been allowed to close down, and proper care has not been exercised to see that all burners are lighted again, or the burner cocks shut off.

On the other hand, by the use of the prepayment meter, bad bills become things of the past, and this more than compensates for the expense of the frequent visits of the collectors to empty the cash boxes. Gas stoves and lighting fixtures are sold, and the consumption of gas is increased in numerous ways, due largely to this "pay as you use" type of meter. Consumers are obtained and held who would not use gas if delivered through an ordinary meter. However, a large percentage of such consumers are apt to be unprofitable and the company would be better off without them, except in those situations where there is a "readiness to serve" charge.

In one large city, under a contractual obligation to render quarterly bills, the prepayment meter was welcomed as a means of avoiding a large credit to many small consumers purchasing appliances on the instalment plan. However, an unexpected demand came from the general body of consumers, and now 60 per cent of all the meters are of the prepayment type. As this type is not adapted to a sliding scale of prices, and such a scale will form the future gas vending standard, prudence counsels conservatism in the purchase of prepayment meters for any situation.

It is apparent from the above that a prepayment meter should not be set where an uninterrupted gas supply is important. This applies in general to all situations where there are pilot lights, and with special force where there are large gas-consuming appliances, such as automatic instantaneous water heaters equipped with pilot lights. Neither are they suitable for connection in parallel, as this would be apt to involve, from time to time, the entire supply of gas being delivered through one meter, resulting in its detriment through overload, and in poor service.

Other Types

In addition to the wet and dry tin meters in general use, there are several cast iron designs used more or less extensively. Various kinds of valves and valve motions and compensating indices for registering high pressure gas are employed with varying degrees of success. The open-top meter is being tried again on a rather extensive scale by a few companies. In it, the gas from the inlet column passes directly under the top of the meter to the valves placed on the table, but not inclosed in a small valve chamber, as in the ordinary dry type. The advantage claimed is reduced cost of repairs, due to the ease

with which the valves may be cleaned or reground. With a gas of good quality, however, this should not be a frequent necessity in any meter.

Nomenclature

In the early stages, a 5-light meter, for example, was designed to measure only enough gas per hour to supply five burners consuming 6 cubic feet each, or a total consumption of 30 cubic feet. Inasmuch as this original working capacity has been increased from time to time to 140, or more, cubic feet per hour, equivalent to twenty-three 6-foot burners, it is readily seen that the term "light" does not now afford any exact indication of the capacity of this meter.

The value of a "light" is not the same in small meters as in large meters. For example, a 3-lt. meter can supply easily per hour 50 cubic feet, while a 100-lt. meter should not be required to pass more than 600 cubic feet, which makes the value of a "light", in the first case, nearly 17 cubic feet, and in the second case, only 6 cubic feet per hour.

Marked differences exist in actual capacities, as compared with nominal sizes, due to the fact that increases in capacity have been made by some manufacturers and not by others; therefore, when more than one make is included in a stock of meters, it becomes necessary, in drawing up a table of capacities, to rate each nominal size at, or slightly above, the smallest capacity of that size. This also may be true with but one make of meter in use, for if made in different years, their capacity sometimes may vary as much as 100 per cent.

Standardization of Size

Advisability

In spite of the fact that many meters have been put on the market, with intention to displace the two-diaphragm, plain "D", slide-valve, dry gas meter, this good, but badly abused, friend of the gas man still continues preëminent as arbiter between the company and the consumer. There is every indication that this will be true for a time long enough to warrant an earnest effort to replace the obsolete and, as we have shown, more or less hazy classification by "light," by a definite capacity designation for each size.

The volume of gas which will pass through a meter in a given time depends, among other things, on the pressure thereby

absorbed. There are three causes for this pressure loss: mechanical friction of the working parts, which increases proportionally to the working speed; straight fluid friction, which increases as the square of the volume of flowing gas; and fluid friction, due to the numerous changes in flow direction. There is no general agreement as to what drop in pressure between the meter inlet and outlet it is safe to allow without interfering with safe working conditions. Some gas engineers set the limit at 0.3 inch water column, while others maintain that a 0.5 inch differential is not too great. The safe differential is, no doubt, slightly lower than that at which the supply to the burners shows, by its fluctuation, that the meter is being overworked. Numerous tests of a large number of different makes of meters have proven that not until 0.7 inch loss in pressure is reached is there a decided fluctuation in pressure.

Where capacities vary for the same nominal size, it has been noted already that a table of capacities, to be safe, must be based on the smallest capacity for each size. Such a table has its principal application in determining a meter-setting schedule, and in this connection, the advantage of a uniform relation between actual capacity and nominal size is, indeed, very great.

Again, in order that meter work in consumers' houses may be done quickly, properly and cheaply, it is necessary that the leading dimensions, viz, height from bottom of meter to top of meter screws, distance from center to center of meter screws, and size of meter screws, should be the same for all makes of each nominal size of meter. This is especially true when *all-iron* connections are used, as when the distance between the center of screws is not the same, there is a great temptation, when changing meters or when setting a meter on existing connections, not to change the piping, but rather to make the old piping do for the new meter. The meter when thus connected is apt to be subject to strained screws and column seam leaks.

Suggested Standard

Notwithstanding the advantages to be gained, as above explained, by a meter standard based on a uniform capacity under a given differential pressure and size of case, there has been no attempt on the part of the gas companies and the meter makers to arrive at such a standard, though the subject has been discussed in meetings of various gas associations, and the desirability of definite action widely recognized. At the 1907

meeting of the American Gas Institute, a standard was suggested as follows:

Size	*Hourly Capacity (Cubic Feet)	†Height (Inches)	‡Width (Inches)	Size Screw
5-lt.	°100	16	$11\frac{1}{8}$	5-lt.
5-A	175	16	$11\frac{1}{8}$	5-lt.
10-A	375	$17\frac{1}{2}$	$13\frac{1}{8}$	10-lt.
30-A	875	25	$18\frac{5}{8}$	30-lt.
60-A	°1800	$33\frac{1}{4}$	25	60-lt.
150-A	3400	$42\frac{3}{4}$	32	150-lt.

*With 0.5 inch differential pressure and a gas with specific gravity of .55.

†From bottom of meter to top of meter screw.

‡From center to center of meter screws.

°The capacity of the 5-lt. ordinary meter has since been changed to 140 cu. ft., the 5-lt. prepayment meter to 125 cu. ft., the 60-A to 1500 cu. ft., and the new meters badged accordingly.

It also was urged that in adopting a standard, no additional details were advisable, as the manufacturers should not be expected to construct meters on exactly the same lines, but should be allowed to follow their own designs, and, in the long run, the best make, or makes, of meter would win out.

The above standard has been in use in Philadelphia for more than ten years, and has proven satisfactory. It also has been accepted by many other companies. The arguments in its favor are as follows:

Nomenclature: The shortest method of designating the sizes and capacities is obtained; as, for instance, a 5-A suggests immediately a meter of the same general dimensions as the ordinary 5-lt. meter, and a known working capacity of 175 cubic feet per hour.

Range of Sizes: In any standard, the 5-lt. meter is necessary, as it is now the size in most general use and will care for the needs of 80 to 90 per cent of consumers, and is slightly cheaper to make than the 5-A. The 5-lt., however, is the only old size that should find place in a new standard. With the 5-A more than equal in capacity to the 10-lt., the 10-A to the 20, 30 and 45-lt., etc., the economy involved in the use of the smaller sized case is too pronounced to justify any other course. For instance, the purchase price of a 10-A is about 35 per cent of that of a 45-lt. Also, with the decreased size of case for the same capacity, comes economy in connection cost. The abolition of flanged

connections, made possible by the proposed schedule, is a very important item along this line.

The old-time meter schedule, ranging from 3- to 500-lt., contained at least twelve sizes. Cutting this number in half effects an appreciable reduction in idle stock and in maintenance costs, while still affording a range of capacities whose differentiation is fully as close as is the accuracy with which it is possible to determine the maximum requirements of a prospective consumer.

Capacities and Dimensions: The capacities and the two important case dimensions are given. In ordering and in using meters, a knowledge of these dimensions is almost as important as that of capacities. The dimensions of the "A" meters correspond closely to those of the same nominal size of the old standard, and with the adoption of a meter screw of the same nominal size, a perfect interchangeability between the "A" and "light" meter of the same number is obtained. The meter screw, as part of the meter union, is at present the only appurtenance of a meter that is standard for all makes.

Alternative Schedule

Another departure from the long-accepted capacity standard is embodied in the "B" meters, in wide use and with sizes and capacities, at 0.5 inch loss, as below:

Size	Hourly Capacity (Cubic Feet)
3–B	104
5–B	158
10–B	280
20–B	400
30–B	609
60–B	1303
100–B	1864
200–B	3150
300–B	Under development

In these meters, and some other makes as well, the excellent practice is followed of soldering on a brass badge to show the capacity under a 0.5 inch loss in pressure through the meter.

CHAPTER XLVII

CONSTRUCTION AND ACTION

General

The meter is such an important factor in distribution that a thorough explanation of its construction and operation is desirable, and to that end much thought has been given to the illustrations of the two-diaphragm, "D" slide-valve type that accompany this chapter. Figures 112 to 118 inclusive are photographs. Figures 112 to 114 show what may be considered the "bones" of a meter. Figures 115 to 118 contain all of the working parts, though it will be noted that one side of each valve has been cut away to disclose the relation between valve and seat. Figures 119 to 122 are drawings, with each part plainly numbered, and accompanied by tables of names. From the knowledge thus obtained of each part, the identification of most of them in the preceding photographs will be fairly easy, especially after reading the text and the explanation of how a meter operates. This explanation is facilitated greatly by Figures 123 to 126, diagrammatically illustrating the four points of cut-off.

So far the reference has been to the ordinary meter. A prepayment mechanism is shown by two photographs, Figures 127 and 128, and a drawing, Figure 129.

In the text, the principal parts usually will, when first spoken of, be connected with one or more of the illustrations in which they are shown. This does not seem necessary in the case of most of the small parts, as they may be found easily on the drawings. Where letters are used to designate parts of which there are two, one in the front half and the other in the back half of the meter, a capital letter will be used for the former, and a small letter for the latter.

Principle of Measurement

Before giving the detailed construction and operation, the principle by which the dry meter measures gas will be described.

This principle is the same as the one by which the quantity of liquid drawn from a cask may be measured by drawing the contents through a spigot into a quart measure located under the spigot, emptying the quart measure each time it is filled, through a cock-controlled opening in its bottom, and then counting the number of measures thus emptied. To ensure the accuracy of this method, the following conditions must be fulfilled: (a) The measure must contain accurately one quart. If it is too large or too small, manifestly the total volume drawn will be inaccurately measured; (b) while the measure is being filled at the spigot, no liquid must be allowed to escape into the receptacle for the measured liquid. If there is a small hole in the bottom of the quart measure, or a leak at the cock, it is evident that the total measurement will be vitiated; (c) after the quart measure has been filled, the spigot must be completely closed before the measure starts to empty. If, during the process of emptying, some additional liquid should escape into the emptying measure, it is evident that the total measurement will be incorrect; (d) an accurate count must be kept of the number of measures so filled and emptied. It is evident that a wrong total volume will be reached if this count is not accurate.

The process then consists in (1) filling a measure of standard volume, (2) then completely shutting off the supply, (3) then completely emptying the measure before again opening the supply, and (4) keeping an accurate count of the number of measures so filled and emptied.

Now, the meter measures, by this same method, the volume of gas delivered. Instead of one measure being alternately filled and emptied, in the meter there are four of these standard measures in operation simultaneously, some filling while others are emptying. This ensures a uniform delivery of the gas, instead of the intermittent delivery which would be necessitated by the operation of one measure.

Each of these measures is, in the meter, the volume displaced by a piston (diaphragm disc) in making a stroke. The construction of the meter is such that this displaced volume is capable of accurate and delicate adjustment. By altering the length of the stroke, the volume displaced may be increased or decreased, and when the correct volume is reached, the mechanism may be clamped so that this correct stroke is maintained. This process of changing the volume displaced by the stroke of the

diaphragm disc and fixing it in the correct position, is called "adjusting the meter"; it will be described in detail later.

When the diaphragm disc is making a stroke, the space behind it is filling with gas; it is, therefore, open to the incoming supply of gas, and shut tight to the outlet pipe from the meter. At the same time, the space in front of the disc is delivering gas; it is, therefore, shut tight against the incoming supply of gas, and open to the meter outlet. At the moment the disc reaches the end of its stroke, the space behind it, which has been filling with gas, is automatically shut off from the source of supply, and almost immediately afterward, this space is automatically opened to the meter outlet. During the brief period in which this space is thus shut off from both inlet and outlet, the measurement of this measureful of gas is made. The same thing is happening on the other side of the disc,—when the space on one side is emptying, the space on the other side is filling.

This automatic closing and opening of these compartments is accomplished by an ordinary slide valve. In the meter, there are two separate chambers (or cylinders), each with its own piston (or diaphragm disc), and consequently, there are two slide valves.

Having adjusted the meter so that each stroke of either one of the diaphragm discs displaces accurately the desired volume of gas (our standard measure), and having set the slide valves so that when each measure is full, it is shut off from the inlet before it is opened to the outlet, we must now arrange to ensure an accurate count of the number of measures thus filled and emptied. This is accomplished by mechanically gearing the two diaphragm discs to a dial, so that each stroke of the discs is accompanied by a corresponding movement of the hand on the dial. Now, if this dial was divided so as to show the number of strokes made, then by taking this number and multiplying it by the standard fraction of a cubic foot that the two discs are known to displace in a stroke, the volume of gas passed may be obtained. To avoid the necessity of making this multiplication each time the meter is read, the mechanism of the dial is made so that it automatically makes the multiplication, and enables one to read the result direct in cubic feet. This is as if, in the first illustration of measuring a liquid in quart measures, a lever were arranged so as to mark, not every quart measure emptied, but only once for each four measures emptied, and the number of marks so made would be counted as so many gallons. In other words, while the number of fillings and emptyings is

what is really being counted, the result on the dial is shown in terms of gallons. So in the meter, while the dial really counts the number of strokes made by the two diaphragm discs, the result is shown in cubic feet,— a practice entirely justified, because, as already explained, it is known that so many strokes must mean the delivery of a definite and accurately known volume of gas.

In practice, the speed at which a meter works, or the rate at which gas passes through it, depends upon the demand on its outlet, i. e., on the number and size of the burners or appliances the consumer may have in use at one time. It is important that the meter should register the gas with equal accuracy, whether the rate of gas passage is slow or rapid. It is evident that if the valves are not set correctly, so as to open and close the inlets and outlets of the measuring chambers at the proper times, while it might be possible, by adjusting the strokes of the diaphragm discs, to obtain a correct measurement at any one speed of the meter, yet the measurement would be incorrect at all other speeds. When the valves are set symmetrically, a correct measurement at one speed will be correct at all others. New meters and old meters in which some derangement of the mechanism may have occurred, should be tested to show their standing as to this point. In case a meter does not pass this test satisfactorily, the process by which it may be corrected so as to measure correctly at both low and high speeds, is known as "setting the valve"; it will be described in detail later.

It should be explained that any absorption of the pressures of gas in operating the meter, or in the passage of gas through the meter, has no appreciable effect on its volume. Gas pressures are stated in terms of a water column sustained above the pressures of the atmospheres. As this is about 14.7 pounds per square inch, and as ordinary gas pressures, say, 2 to 4 inches water column, are less than one-sixth of a pound per square inch above the atmospheric pressure, it is evident that a change of several inches in the water column pressure of the gas will make exceedingly slight changes in its volume or density. It follows that for all ordinary ranges of pressure, the meter is equally accurate in its registration.

Ordinary dry meters are constructed so that the pressure of the gas in them should not be higher than one pound, or 27 inches of water column.

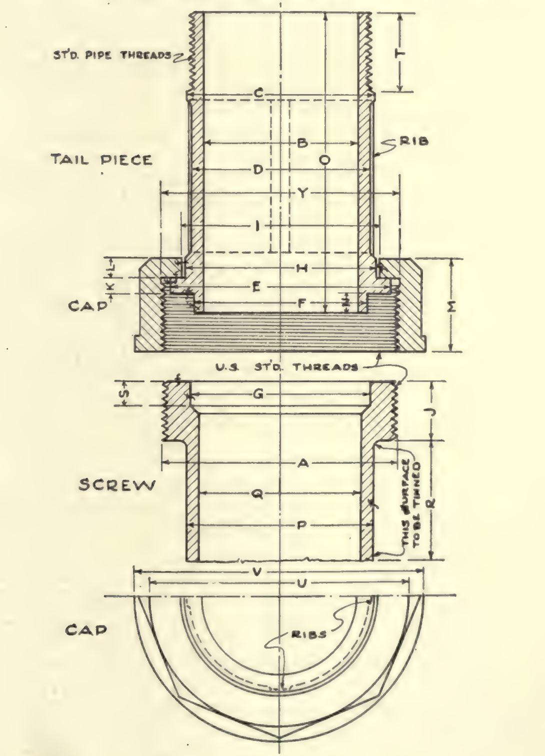
Figure 109.—Consumer's Meter, page 420: S, Screw; U, Side Pipe.

Construction

The meter case, Figure 109, is made up of tinned iron plates, soldered together in the form of a rectangular box. A long tin column or side pipe, U, is soldered to each side. The one on the reader's left is the inlet column, and the one on the right, the outlet column. In the top of each is placed a brass spud or

STANDARD METER UNION

CAP AND TAIL PIECE MAY BE EITHER BRASS OR MALLEABLE IRON
SCREW TO BE OF BRASS.



NOTES

FINISH SURFACES WHERE MARKED f.
RIBS ON TAIL PIECE SHOULD BE AT LEAST ¼" WIDE. SPACED 90° APART AND SHOULD NOT PROJECT BEYOND SHOULDER "C".
SHANK OF SCREW MAY BE OF ANY DESIGN OR GREATER LENGTH THAN "R"; THE WINGED & RIVETED TYPE PREFERRED.

Figure 110.—Meter Union, page 422.

meter screw S, by which the inlet column is connected to the service and the outlet column to the house piping.

The old method of sweating the screw, Figure 110, into the columns, did not produce sufficiently strong joints to withstand the strains caused by all-iron connections, or by one lead and one iron connection. One modern improvement is to lengthen the shank of the screw to secure a longer solder joint between screw and side of meter. Another, and still better, device is to make the shank still longer, and cast lugs on each side, by which the screw is riveted to the meter. The riveted screw affords a very secure method of attachment, and is the type now generally employed, though greater difficulty is experienced in renewing these screws when damaged.

A simple and effective means of strengthening the sweated joint of the old standard straight shank screw, is to anchor the screw to the top of the column by a single rivet. This rivet is put in easily at the time of sweating the screw into the column, and is removed easily when replacing a damaged screw.

The standard meter cap, Figure 110, is of octagonal shape, but in the report of the American Gas Institute's Committee on Consumers' Meters, as printed on page 861 of the 1916 Proceedings, there is a drawing of a round cap and some arguments for its use. As yet, however, it has been tried by one company only, and no reliable data are now available.

The tailpiece, Figure 110, as well as the entire meter union, always was made of brass, until in recent years it has been found that for the tailpiece and the cap, malleable iron, black or galvanized, is cheaper and equally satisfactory.

Figure 111 gives the standard dimensions of all sizes of meter unions, the letters in the table being those shown in Figure 110.

The inside of the meter is divided, Figure 112, into three compartments by a horizontal and a vertical partition. The space in the upper part, above the horizontal partition, or table, is called the gallery G. The space below the table is divided into two equal compartments, Z and *z*, by the vertical partition, placed midway between the front and back of the meter. A small gas-tight compartment, called the valve chamber, Y, is constructed in the gallery, and contains the valves which control the passage of the gas in and out of the compartments below the table.

The measuring apparatus below the table in each of the two compartments formed by the vertical partition, consists of a

SIZE	3 LIGHT	5 LIGHT	10 LIGHT	20 LIGHT	30 LIGHT	45 LIGHT	60 LIGHT	100 LIGHT	150 LIGHT	200 LIGHT
A	$\frac{63}{64}$	$1\frac{1}{8}$	$1\frac{7}{16}$	$1\frac{53}{64}$	$2\frac{3}{64}$	$2\frac{17}{64}$	$2\frac{7}{16}$	3	$3\frac{1}{2}$	$3\frac{1}{2}$
B	$\frac{7}{16}$	$\frac{19}{32}$	$\frac{13}{16}$	$1\frac{1}{32}$	$1\frac{11}{32}$	$1\frac{17}{32}$	$1\frac{9}{16}$	$1\frac{31}{32}$	$2\frac{13}{32}$	$2\frac{13}{32}$
C	$\frac{11}{16}$	$\frac{27}{32}$	$1\frac{1}{16}$	$1\frac{5}{16}$	$1\frac{21}{32}$	$1\frac{29}{32}$	$1\frac{29}{32}$	$2\frac{3}{8}$	$2\frac{7}{8}$	$2\frac{7}{8}$
D	$\frac{41}{64}$	$\frac{13}{16}$	$1\frac{1}{16}$	$1\frac{9}{32}$	$1\frac{5}{8}$	$1\frac{27}{32}$	$1\frac{27}{32}$	$2\frac{5}{16}$	$2\frac{13}{16}$	$2\frac{13}{16}$
E	$\frac{7}{8}$	1	$1\frac{5}{16}$	$1\frac{5}{8}$	$1\frac{29}{32}$	$2\frac{1}{8}$	$2\frac{1}{4}$	$2\frac{13}{16}$	$3\frac{5}{16}$	$3\frac{5}{16}$
F	$\frac{21}{32}$	$\frac{3}{4}$	1	$1\frac{5}{16}$	$1\frac{1}{2}$	$1\frac{45}{64}$	$1\frac{29}{32}$	$2\frac{7}{32}$	$2\frac{5}{8}$	$2\frac{5}{8}$
G	$\frac{11}{16}$	$\frac{13}{16}$	$1\frac{1}{16}$	$1\frac{3}{8}$	$1\frac{35}{64}$	$1\frac{3}{4}$	$1\frac{31}{32}$	$2\frac{9}{32}$	$2\frac{11}{16}$	$2\frac{11}{16}$
H	$\frac{23}{32}$	$\frac{7}{8}$	$1\frac{3}{32}$	$1\frac{11}{32}$	$1\frac{11}{16}$	$1\frac{15}{16}$	$1\frac{15}{16}$	$2\frac{7}{16}$	$2\frac{15}{16}$	$2\frac{15}{16}$
I	$\frac{3}{4}$	$\frac{29}{32}$	$1\frac{1}{8}$	$1\frac{13}{32}$	$1\frac{23}{32}$	$1\frac{31}{32}$	$1\frac{31}{32}$	$2\frac{1}{2}$	3	3
J	$\frac{3}{8}$	$\frac{13}{32}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{3}{4}$	1	1
K	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{5}{32}$	$\frac{5}{32}$	$\frac{5}{32}$	$\frac{5}{32}$	$\frac{3}{16}$	$\frac{9}{32}$	$\frac{9}{32}$
L	$\frac{3}{32}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{5}{32}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$
M	$\frac{19}{32}$	$\frac{41}{64}$	$\frac{11}{16}$	$\frac{13}{16}$	$\frac{57}{64}$	$\frac{31}{32}$	$\frac{31}{32}$	$1\frac{3}{16}$	$1\frac{17}{32}$	$1\frac{17}{32}$
N	$\frac{5}{32}$	$\frac{5}{32}$	$\frac{5}{32}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{5}{16}$
O	$2\frac{1}{8}$	$2\frac{3}{16}$	$2\frac{5}{16}$	$2\frac{3}{4}$	$2\frac{7}{8}$	3	3	$3\frac{13}{16}$	4	4
P	$\frac{3}{4}$	$\frac{13}{16}$	$1\frac{1}{16}$	$1\frac{7}{16}$	$1\frac{5}{8}$	$1\frac{13}{16}$	2	$2\frac{3}{8}$	$2\frac{13}{16}$	$2\frac{13}{16}$
Q	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{7}{8}$	$1\frac{1}{4}$	$1\frac{13}{32}$	$1\frac{9}{16}$	$1\frac{3}{4}$	$2\frac{1}{16}$	$2\frac{1}{2}$	$2\frac{1}{2}$
R	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{3}{8}$	$1\frac{5}{8}$	$1\frac{5}{8}$	$1\frac{5}{8}$
S	$\frac{3}{16}$	$\frac{7}{32}$	$\frac{7}{32}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{7}{16}$	$\frac{7}{16}$
T	$\frac{9}{16}$	$\frac{9}{16}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{7}{8}$	1	1	1	$1\frac{1}{4}$	$1\frac{1}{4}$
U	$1\frac{9}{64}$	$1\frac{19}{64}$	$1\frac{5}{8}$	2	$2\frac{7}{32}$	$2\frac{15}{32}$	$2\frac{21}{32}$	$3\frac{5}{16}$	$3\frac{13}{16}$	$3\frac{13}{16}$
V	$1\frac{11}{32}$	$1\frac{1}{2}$	$1\frac{27}{32}$	$2\frac{9}{32}$	$2\frac{1}{2}$	$2\frac{13}{16}$	3	$3\frac{11}{16}$	$4\frac{1}{4}$	$4\frac{1}{4}$
Y	1	$1\frac{5}{32}$	$1\frac{15}{32}$	$1\frac{55}{64}$	$2\frac{5}{64}$	$2\frac{19}{64}$	$2\frac{15}{32}$	$3\frac{1}{32}$	$3\frac{17}{32}$	$3\frac{17}{32}$
TH'DS PER IN. ON SCREW	18	12	$11\frac{1}{2}$	$11\frac{1}{2}$	$11\frac{1}{2}$	$11\frac{1}{2}$	$11\frac{1}{2}$	$11\frac{1}{2}$	$11\frac{1}{2}$	$11\frac{1}{2}$
ST'D. PIPE TH'DS FOR TAIL PIECE	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$	$2\frac{1}{2}$

Figure 111.—Dimensions of Standard Meter Unions, page 422.

flexible diaphragm, D and *d*, Figure 115, mounted in a central position on each side of the partition, so that no portion of the

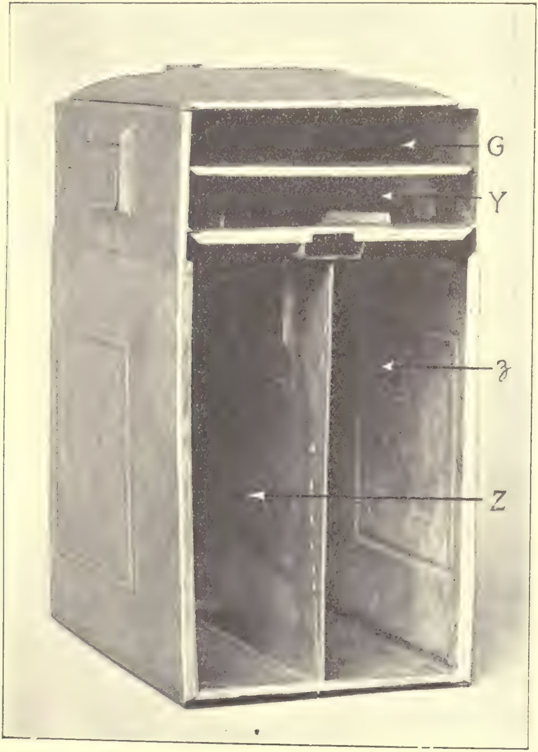


Figure 112.—Consumer's Meter, Side View—Outlet Side and Working Parts Removed, page 112: G, Gallery; Y, Valve Chamber; Z, z, Compartments.

diaphragm when deflated, or inflated, will touch the metal of case or partitions. There are thus formed four distinct measuring chambers, viz., the two interiors of the diaphragms themselves, and the two spaces outside, known as diaphragm chambers, C, *c*, Figure 115.

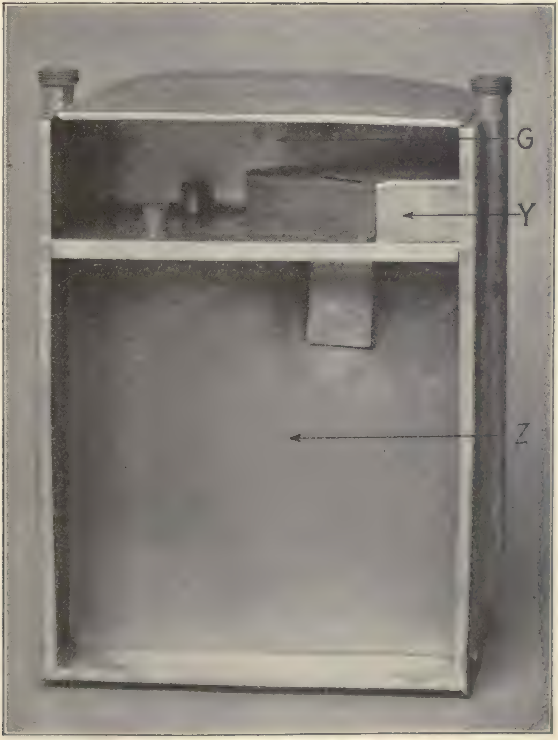


Figure 113.—Consumer's Meter. Front View—Front and Working Parts Removed page 430: G, Gallery; Y, Valve Chamber; Z, Compartment.

It will be noted that the weight of the diaphragm is supported by an arm, or flag, F, Figure 117, attached to the diaphragm disc X by means of a diaphragm carriage W. This flag is in turn soldered to a vertical flag rod R, which rests in a step mount-

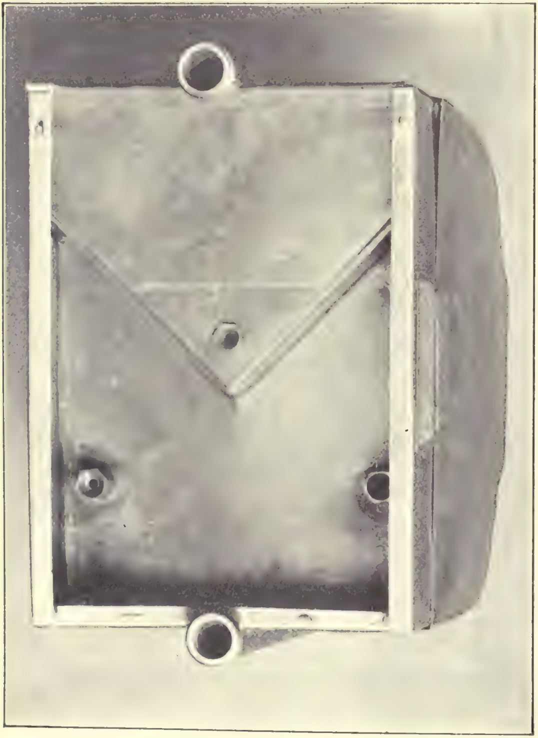


Figure 114.—Consumer's Meter. Top View—Top and Working Parts Removed.

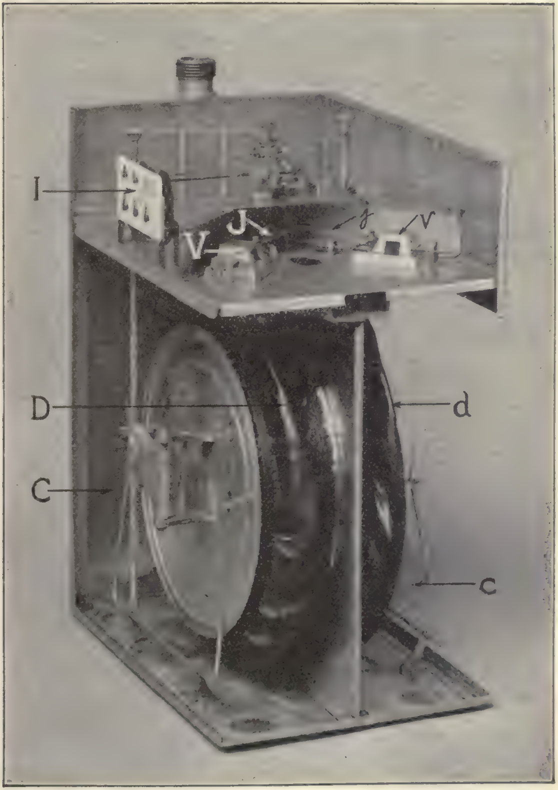


Figure 115.—Consumer's Meter. Front and Side View—Valves Cut Away, page 424: C, c, Diaphragm Chambers; D, d, Diaphragms; I, Index; J, j, Valve Arms; V, v, Valves.

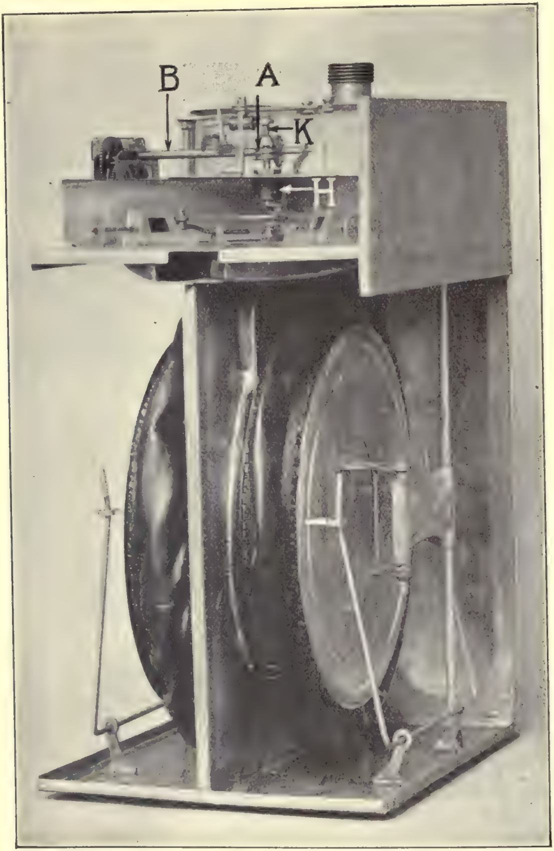


Figure 116.—Consumer's Meter. Back and Side View--Valves Cut Away, page 430: A, Spiral Gear; B, Horizontal Axle; H, Center Stuffing Box; K, Crank.

ed on the bottom of the meter, the rod passing upward through a stuffing box into the gallery. By means of this arrangement, the diaphragm disc is compelled to move in and out always in the

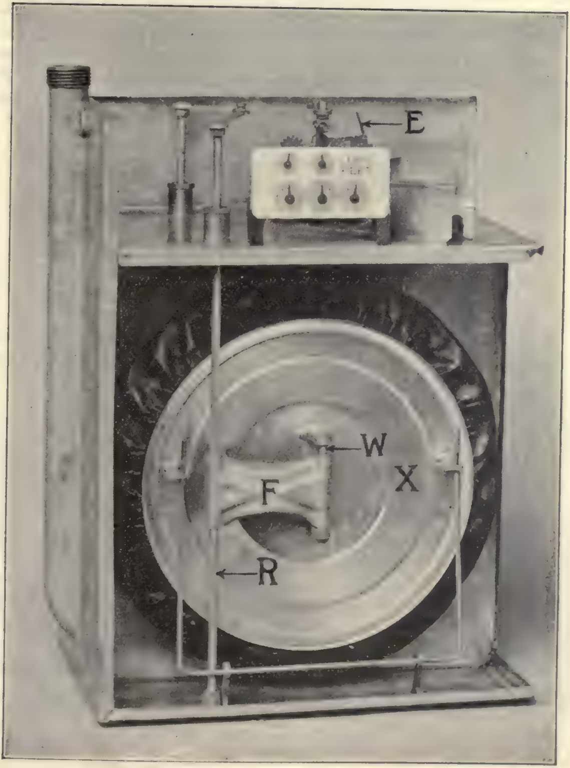


Figure 117.—Consumer's Meter. Front View, page 426: E, Tangent Click; F, Flag; R, Flag Rod; W, Diaphragm Carriage; X, Disc.

same plane. The disc is still further guided by means of a guide wire, which keeps the two guide points of the disc moving at the same speed.

Attached to the upper end of each flag rod is one end of a pair of arms, called the flag arms. The short flag arm, N, Figure 118, is attached loosely to the long flag arm M and to the tangent post L, mounted on the tangent, or tangent arm T. The tangent is rigidly attached at right angles to the top of a vertical shaft, or crank, K, Figure 116, passing through the bridge and center stuffing box H into the valve chamber.

Attached, by means of short valve arms, J, *j*, Figure 115, to the single throw of this crank, are two slide valves, V, *v*, set at an angle of 90° to each other, and which control the flow of gas into and out of the diaphragms and compartments. In each valve seat are three openings or ports. The case port, Q, Figure 118, communicates with the diaphragm compartment or chamber; the outlet port O with the fork channel leading to the outlet column; and the diaphragm port P with the interior of the diaphragm through the pocket channel.

In Figure 118, the port openings show clearly where the valve side has been cut away, but the relation between the valves, ports and channels is shown more clearly in the drawing, Figure 121. Following the gas flow, we have: 1, inlet column; 2, long channel; 4, long channel outlet; 9, case port, or 10, diaphragm port; 13, diaphragm channel; 8, outlet port; 7, fork channel; 5, outlet column. The opening of the fork channel into the outlet column is seen very clearly in Figure 115, as is also the long channel outlet into the valve chamber. The diaphragm channel is seen best in Figure 113. The present tendency is to increase the size of channels and ports within the meter, and thus obtain greater delivery capacity without increasing outside dimensions. The "A" meters are examples of what is possible in this direction.

The recording mechanism, or index, I, Figure 115, is mounted in the front part of the gallery, and its face, or dial, is viewed through a glazed index box. The gearing communicates through the horizontal axle, B, Figure 116, and its gear wheel with the spiral gear A on the crank K.

Action

Motive Power

A meter is in communication, through its inlet column, with gas under pressure from the gas holder through the mains and

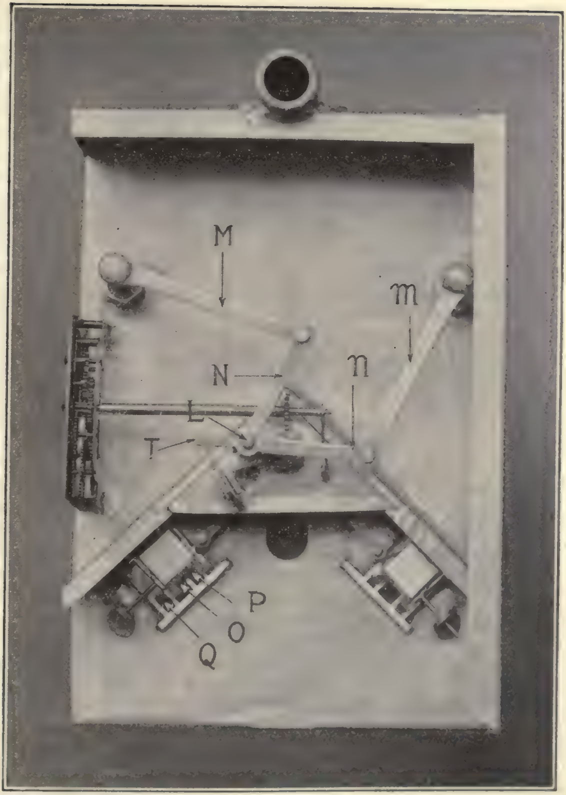


Figure 118.—Consumer's Meter. Top View—Valves Cut Away, page 430: L, Tangent Post; M, m, Long Flag Arms; N, n, Short Flag Arms; O, Outlet Port; P, Diaphragm Port; Q, Case T, Port; Tangent.

the service pipe, and through its outlet column, it connects with piping supplying appliances, which, by the opening of a cock, will allow the escape of gas into the atmosphere. This escape lowers the pressure at the meter outlet, and immediately the gas on the inlet side starts to flow toward the outlet, just as water flows when given a chance to seek a lower level. In its path the gas has to pass through the chambers and channels already alluded to, and in so doing operates the measuring mechanism, as will now be described in detail. First, however, it might be well, in view of the great ignorance on this subject, to emphasize the fact that no movement of the meter, and therefore no registration of the index, is possible without the establishment of a pressure difference through the meter, and as, in turn, such pressure difference will result only from the escape of gas beyond the meter, the latter always is a measure of gas consumption.

The working limits of such pressure difference, and the variation of volume passed with pressure absorbed, have been discussed.

Description of Gas Flow

The inlet column connects through the long channel with the valve chamber. There are just four positions of the valves in which but one measuring chamber is taking gas, and but one emptying through the outlet port to the consumer, all flow having ceased on one side of the vertical partition. These four positions are called points of cut-off. At any other time, the gas in the valve chamber always has two available paths of travel, and these two paths lead, according to the positions of the valves, into (1) two diaphragms, (2) two chambers, or (3) a diaphragm and a chamber. Figures 123 to 126 show, diagrammatically, the conditions at the points of cut-off, the arrows indicating the direction of motion during the cycle just beginning. With the aid of these diagrams, an explanation will be given of how the valves, in moving over their respective ports, direct the gas flow.

To begin with, let us assume that the front diaphragm port P is just being uncovered by its valve V. Figure 123 shows the position of the two valves and diaphragms just before this front diaphragm port starts to open. While the valve V moves to the front, the gas passes through the continually widening port P to inflate the diaphragm D. The latter is half full, as shown

in Figure 124, when the valve V has reached the extremity of its frontward motion and the diaphragm port P is wide open.

As the valve V travels backward closing the port P, the diaphragm D continues to fill and is completely expanded, as shown in Figure 125, at the exact moment the port P is closed. The next instant, the continual backward travel of V opens a communication through the port P between the diaphragm D and the outlet port O, through which the gas in the diaphragm passes out into the fork channel and from there to the outlet column. When V has reached the end of its backward stroke, its position is shown in Figure 126. The port P is entirely open and the diaphragm D half deflated. As V travels forward, the diaphragm continues to empty through the closing port P until V reaches the position shown in Figure 123, where the diaphragm D is entirely empty, and is again ready to fill when V uncovers the port P in repeating the journey already described and beginning a new cycle.

So far we have considered only one of the four measuring chambers, viz., the front diaphragm. An inspection of the four diagrams shows that in any one compartment the conditions are as follows: Diaphragm (interior) empty and (diaphragm) chamber full; diaphragm half full and chamber half empty; diaphragm full and chamber empty; diaphragm half empty and chamber half full. This statement, with the explanation that has been given of the passage of the gas through the front diaphragm, and a study of the diaphragms, will make clear how each valve controls the flow of gas through its two measuring chambers. As has been said before, the valves are set at 90° apart, so that the relative diaphragm conditions are as follows: Diaphragm D empty, and diaphragm *d* half full; D half full, and *d* full; D full, and *d* half empty; D half empty, and *d* empty.

Combining now the two compartments, for the four measuring chambers, we have these simultaneous conditions, as illustrated in the figures given:

Figure	Front Compartment		Back Compartment	
	Diaphragm	Chamber	Diaphragm	Chamber
123	Empty	Full	Half Full	Half Empty
124	Half Full	Half Empty	Full	Empty
125	Full	Empty	Half Empty	Half Full
126	Half Empty	Half Full	Empty	Full

From the above table and description, it is clear that there is no dead center to be overcome, for one diaphragm always is

at mid-stroke when the other is at the end of its stroke, and there is a continuous delivery of gas.

Looking back over the pathway we have followed, we can note the following traps or pockets in which, if condensation accumulates in sufficient quantity, it will seal off the gas supply: the inlet column and long channel, and the outlet column. The latter is most likely to give trouble, as into it the condensation from cold house piping is very apt to drain. In some new types, the long channel is placed above the table top, thus removing the trap here.

Before concluding this account of the passage of gas through a meter, it is advisable to investigate the effect of any deviation of flow from the appointed channels. Such deviation may be in the nature of by-passing within the meter case itself, or of leaks through the case into the outer air. In the latter instance, the consumer often imagines that necessarily he must be paying for this gas. In reality, the only meter leaks that always involve gas which has been measured, and therefore recorded for future charge, are those in the outlet column. Other escapes through the case will be of unmeasured gas, except when the meter is in operation, and then only half of the escape will be measured.

Interior by-passing, which oftenest occurs through holes in diaphragms or metal partitions, or under badly seating valves, usually involves only unmeasured gas, but any escape into the gallery, which, normally, does not contain any gas, may or may not have been previously measured. From the gallery there will be a leak into the room through cracks around the dial glass, unless the latter is tightly puttied in place. Gas in the gallery usually is indicated by a discolored (brown) dial face, but should not lead to the removal of the meter unless there is a leak too large to warrant a repair in place, or the discoloration interferes with meter reading.

Measurement of Gas Flow

Having traced the direction of gas flow, the next step will be to show how the inward and outward movement of the diaphragm is transmitted to recording mechanism. The order of transmission is (Figure 122) through 7, diaphragm carriage; 6, flag; 8, flag rod (13, Figure 120); 12, long flag arm; 29, short flag arm, to 9, tangent post. At this point, the conversion from reciprocating to circular motion is complete; and in the meter

illustrated, the tangent post revolves in a clockwise direction, as experience has proved that this direction is the best practice, though not yet universally adopted. In such a meter, the back valve always is ahead of the front valve, which also is clear from a study of the table of measuring chamber conditions.

As the tangent post revolves, it carries with it the tangent arm 11, Figure 120. This, in turn, revolves 30, the crank, or vertical shaft, which serves two functions. Through a single-throw crank on its lower end, the travel of 17, the valve, is properly timed. The second is the measuring function, and the one in which we are now especially interested. A worm or spiral, 5, is mounted on the shaft just below 6, the bridge. This engages with a toothed wheel 3, soldered on 2, the horizontal axle. Each revolution of the shaft and worm advances the toothed wheel one tooth.

To the front end of the horizontal axle is fastened 25, the pinion axle, which drives the index mechanism and on which is mounted 34, a proving head pointer or "test hand", traveling over the face of a graduated circle, known as 33, the proving head. The number of cubic feet corresponding to a complete revolution of the pointer increases with the meter size, and varies from two to one hundred. In a 5-lt. meter it is two cubic feet. As in this meter the displacement capacity of each measuring chamber is one thirty-second of a cubic foot, and each revolution of the vertical shaft corresponds to the complete emptying of all four measuring chambers, or to one-eighth of a cubic foot, and this quantity is one-sixteenth of two, it follows that for every revolution of the vertical shaft, the horizontal axle must be turned one-sixteenth of its circumference. This will require, with a worm of single pitch, 16 teeth on the toothed wheel.

The above example illustrates how, by a proper relation between worm and toothed wheel, the gas passing through the meter may be measured and recorded accurately. Through suitable gearing, driven from the pinion axle, other pointers are set in motion. These move over circles on the index face. Ordinarily there are three such circles. The circumference of each is subdivided into ten equal spaces, numbered from 0 to 9 inclusive. As a complete revolution of each pointer indicates, respectively, 1000, 10,000 and 100,000 cubic feet, it is easy to record, to the nearest hundred feet, the consumption of gas shown. On larger meters, an additional dial is provided, whose complete revolution corresponds to 1,000,000 cubic feet. As will be better

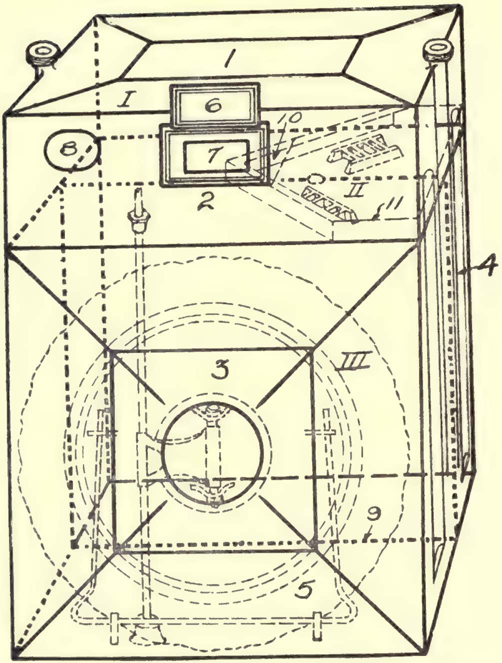


Figure 119.—General View of an Ordinary Meter.

1. Top	4. Side	7. Index Box
2. Front Gallery Plate	5. Bottom	8. Company's Badge
3. Front	6. Index Box Cover	9. Partition

10. Three Cornered Plate 11. Back Plate

I. Gallery II. Valve Chamber III. Diaphragm Chamber

(Plain figures show surfaces; roman figures spaces.)

understood later, each consumer requires a meter of sufficient dial capacity to ensure that between two meter readings, the gas consumption will be less than the capacity of the largest circle.

It probably is clear now that if the meter connections were reversed so that gas entered at the outlet and left at the inlet, the recording mechanism would register backward, which would make it possible for a dishonest consumer to use gas that would not be charged against him. Fortunately, the tangent click, E, Figure 117, affords a simple and effective protection against such a practice. The tangent arm, when revolving in the proper direction, comes in contact, on the side shown by the arrowhead, with the click, which is so mounted on a horizontal pivot that its upper end is depressed below the plane of the tangent arm. Should, however, the direction of the tangent be reversed and it approach the click from the other side, the latter would change to a vertical position, in which it would hold, by reason of the bridge acting as a stop to its bottom edge. Thus. the tangent arm would be halted and no more gas supplied.

It is evident that with the above arrangement, the tangent arm could never make more than one backward revolution, and if its forward movement had ceased just after the click had been passed, then the possible backward movement would be very small, indeed. Now, it occasionally happens that the pressure on the outlet of a meter will exceed that on the inlet. Most frequently such a condition is due to an actual increase in outlet pressure, caused by a rise in temperature of the gas enclosed in a tight system of house piping, and, more rarely, to a failure of supply to one meter or to a whole region, resulting in an entire absence of inlet pressure. Whatever the cause, the effect is to start a backward meter movement to equalize pressures. If the tangent, in moving backward, hits the click before such equalization takes place, the pressure of the gas in the measuring chambers in communication with the outlet column, will result in a strain on the solder joints at the flag rod top and at the base of the bridge. These strains may be relieved by the lifting of the valves off their seats, such lifting immediately equalizing pressures by opening connections between inlet and outlet columns. However, where the valves are dirty, the force required to lift them, often is greater than the resistance of some of the soldered joints, and, therefore, the pressure strain may result in one or more broken joints. The meters damaged in this way are numerous enough to make well worth while the use of a double-action click, which allows a tangent to pass over it once and stops all backward movement only on the second round, thus insuring at least one complete

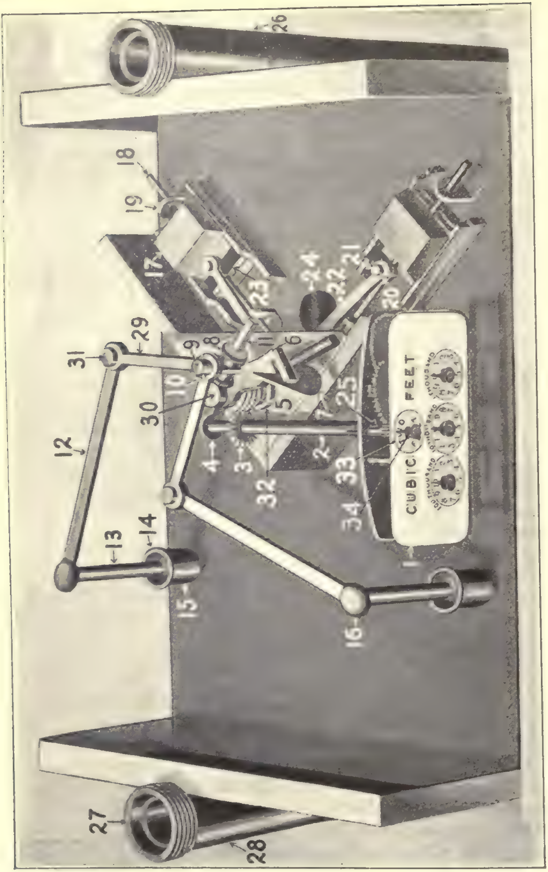


Figure 120.—Parts Above the Table in an Ordinary Meter, page 435.

1. Index
2. Horizontal Axle
3. Horizontal Axle Wheel
4. Horizontal Axle Rest
5. Crank Spiral
6. Bridge
7. Tangent Click
8. Tangent Jamb Nut
9. Tangent Post
10. Tangent Post Pin
11. Tangent Arm
12. Long Flag Arm
13. Flag Rod
14. Flag Rod Stuffing Box Cap
15. Flag Rod Stuffing Box
16. Flag Rod and Flag Arm Solder Joint
17. Valve
18. Valve Wire
19. Valve Guide
20. Valve Wrist Pin
21. Valve Wrist
22. Valve Arm
23. Valve Seat
24. Long Channel Outlet
25. Pinion Axle
26. Outlet Column
27. Meter Screw
28. Inlet Column
29. Short Flag Arm
30. Crank
31. Flag Arm Rivet Joint
32. Crank (or Centre) Stuffing Box
33. Proving Head
34. Proving Head Pointer

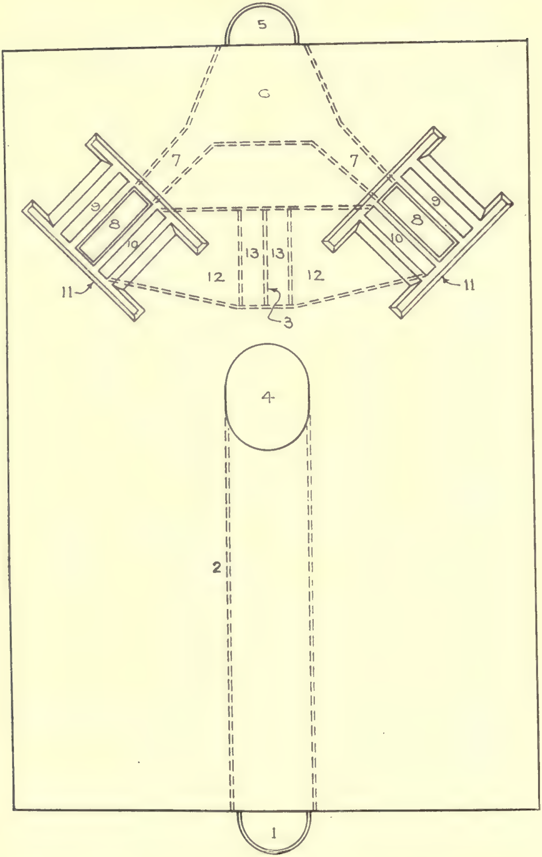


Figure 121.—Consumer's Meter. Valve Seats and Channels.

1. Inlet Column	5. Outlet Column	9. Case Port
2. Long Channel	6. Fork Channel Outlet	10. Diaphragm Port
3. Partition	7. Fork Channel	11. Valve Seat
4. Long Channel Outlet	8. Outlet Port	12. Clam Shell

13. Diaphragm (or Pocket) Channel

revolution, and, therefore, enabling the backward passage of a volume of gas sufficient to equalize pressures in practically all cases of this kind.

Returning now to the proving head circle. It has two uses: the first, as will be described in greater detail later, is to enable the testing of the meter for accurate registration; the second use, which also will be referred to again, is to enable the measurement of small rates of flow. For the latter purpose, the pointer of a 2-ft. proving head sometimes moves at an inconveniently slow pace. To remedy this condition, meters may be obtained now with an extra proving head. In some designs, its pointer moves ten times as fast as the pointer of the regular proving head, which means, in a 5-A meter, that the passage of two-tenths of a cubic foot will cause a complete revolution of this extra pointer, from which it easily is seen how the use of this extra proving head facilitates the measurement of a small volume of gas, or, for a given rate of flow, shortens the time requisite for a given travel of the pointer.

To save the expense of equipping existing meters with a new dial and new gear wheels, and yet obtain a better method of determining the passage of small volumes than is afforded by the ordinary proving head, it is recommended that 3- or 5-lt. meters under repair be provided with a small pointer attached by a hinged joint to the front flag rod and extending to and slightly beyond the top edge of the dial. Any motion of the diaphragm will cause the pointer to move along the dial edge.

Prepayment Attachment

Prepayment mechanisms are constructed on the principle that when a quarter's worth of credit has been made in the meter by inserting a quarter and turning the handle by the fingers, the subsequent passage of a quarter's worth of gas through the meter will exactly reverse the motion in the mechanism, so that it is in precisely the same position as it was before the quarter was inserted. This is accomplished in some designs by a nut traveling on a worm. The turning by the fingers of the handle, after the insertion of the quarter, revolves the worm, and as the nut is prevented from turning, it is forced to travel forward a definite distance on the worm. Subsequently, when the gas begins to pass through the meter, it revolves the nut in the reverse direction to that in which the worm revolved before, and as the worm is kept from turning, the nut is forced to travel back on the

worm, and when it reaches the point from which it first started, exactly a quarter's worth of gas has passed.

Of course, several quarters may be inserted, one after the other, the handle being turned after each insertion, and this results in

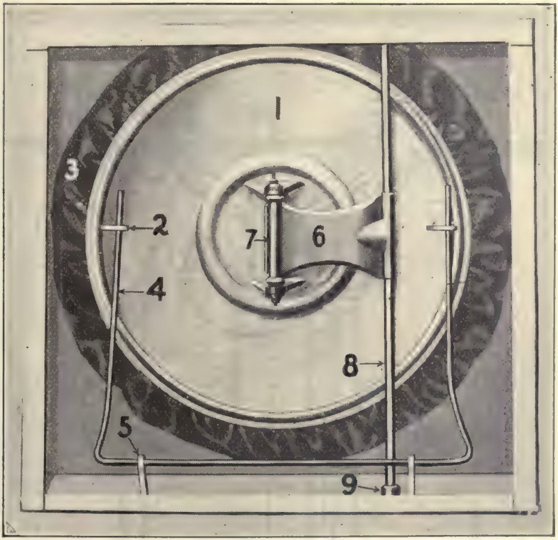


Figure 122.—Consumer's Meter. Diaphragm Chamber.

1. Disc
2. Disc Guide
3. Leather Diaphragm
4. Disc Guide Wire
5. Disc Wire Boot
6. Flag
7. Diaphragm Carriage
8. Flag Rod
9. Flag Rod Step

the nut being advanced by equal increments further and further along the worm. The subsequent passage of gas results in the backward travel of the nut by equal increments for each quarter's worth of gas. When the nut is at the starting end of the worm, it is so connected with a valve in the meter that

this valve is shut, so that no gas may enter the measuring portions of the meter, and, consequently, the meter cannot work. The

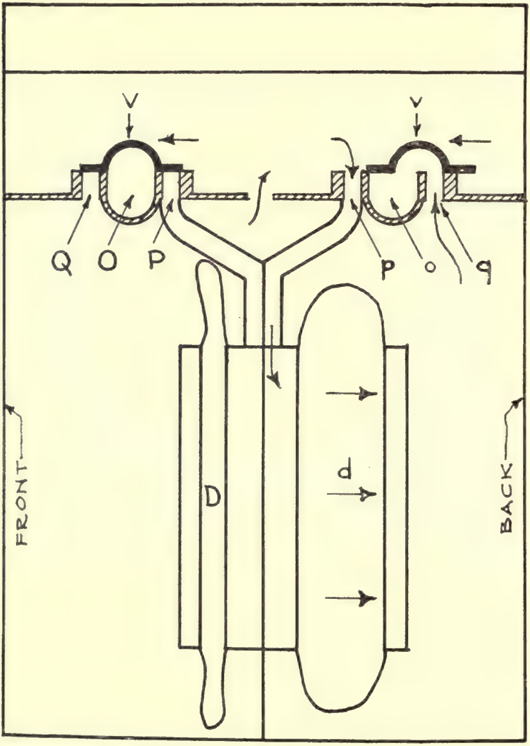


Figure 123.—Consumer's Meter—Point of Cut-off. Front Compartment: Diaphragm empty, chamber full. Back Compartment: Diaphragm half full, chamber half empty.

turning of the handle after inserting the first quarter, causes the nut to travel on the worm so as to open the valve. Con-

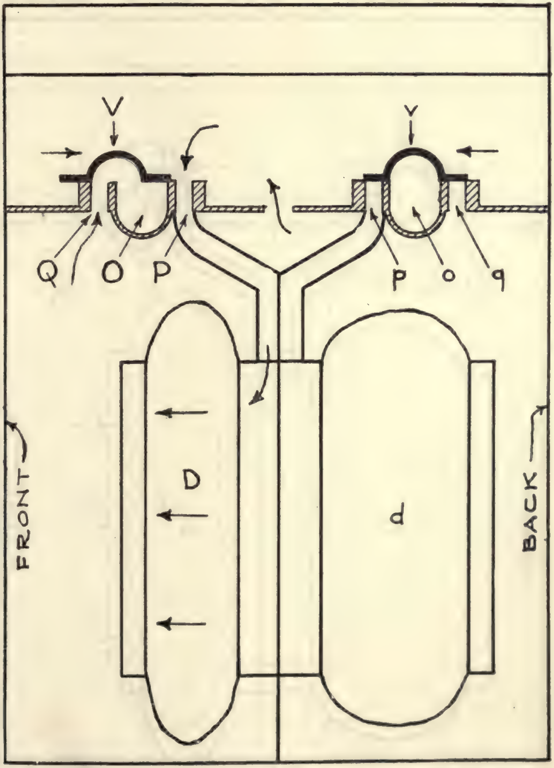


Figure 124.—Consumer's Meter—Point of Cut-off. Front Compartment: Diaphragm half full, chamber half empty. Back Compartment: Diaphragm full, chamber empty.

versely, when the last quarter's worth of gas has been consumed, the nut has returned to its home position, and this results in closing the valve, thus shutting off the passage of any gas.

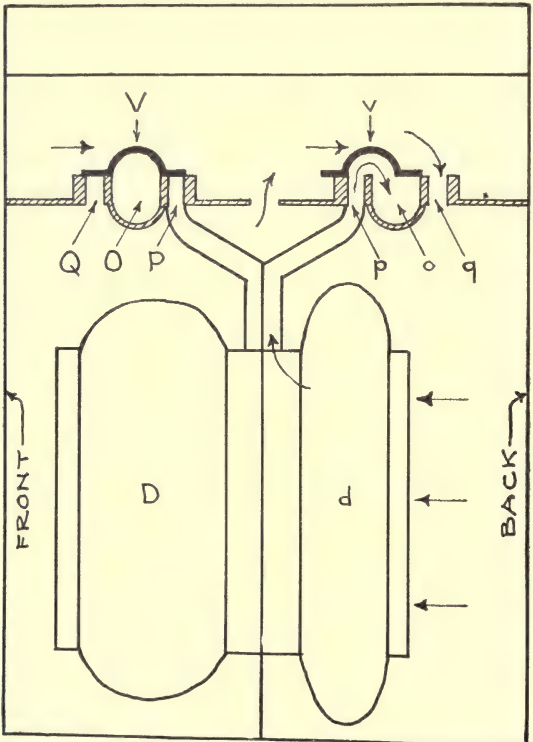


Figure 125.—Consumer's Meter—Point of Cut-off. Front Compartment: Diaphragm full, chamber empty. Back Compartment: Diaphragm half empty, chamber half full.

In another design of prepayment mechanism, instead of a nut and worm, what is known as a planetary gear is utilized. A

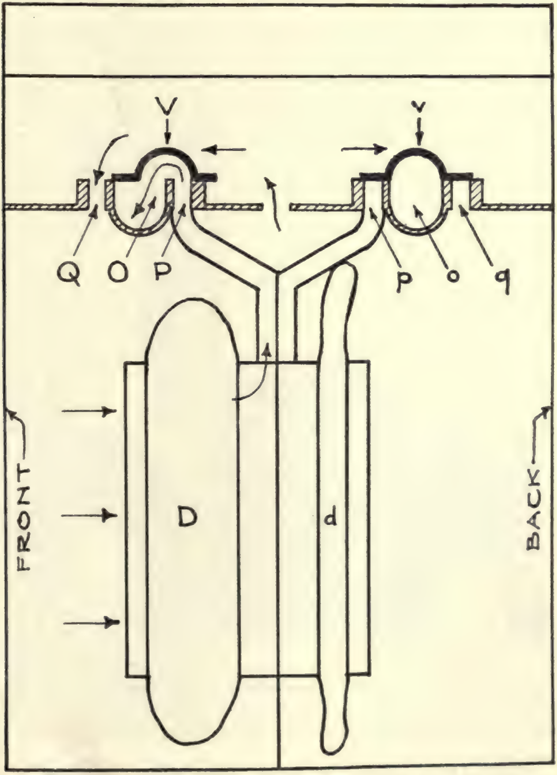


Figure 126.—Consumer's Meter—Point of Cut-off. Front Compartment: Diaphragm half empty, chamber half full. Back Compartment: Diaphragm empty, chamber full.

large wheel, with teeth on the inner face of its rim, is turned in the operation of buying gas. Meshed with these inner teeth

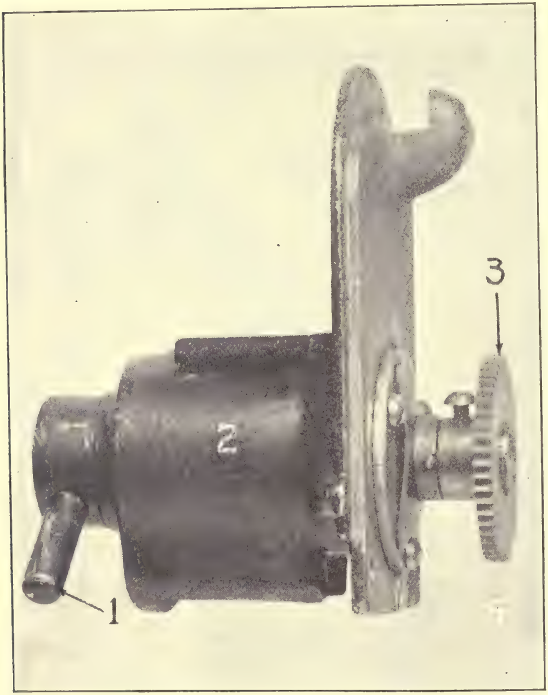


Figure 127.—Slot Part of Prepayment Meter, page 449.
1. Handle. 2. Cylinder or Slot Part. 3. 50-tooth Wheel. 4. Buffer Plate.

are two small gear wheels, mounted on each end of an arm centrally attached to a worm, which, in turn, operates the pre-

payment valve. Each of these small gear wheels mesh with a larger gear wheel located centrally between them. This central gear wheel is attached to the end of a shaft, which is caused to revolve by the passage of gas through the meter. When the handle is turned in the operation of buying gas, the small wheels revolve around the central wheel, which is prevented from turning at this time. As gas passes through the meter, the central wheel revolves, while the large wheel is prevented from so doing. The direction of rotation of the central wheel is such as to cause a reverse direction of rotation of the small wheels on the arm, so that the passage of a quarter's worth of gas through the meter causes them to return to their home position, closing the prepayment valve.

The above design is free from a number of mechanical defects inherent to older types, and will, it is believed, prove its value wherever tried.

In all types of prepayment meters, there is, of course, a provision for changing the price of gas, or what is a quarter's worth of gas.

Figures 127, 128 and 129 illustrate a prepayment mechanism in general use. It is of the worm and nut type, and its action in a 5-lt. meter is briefly as follows: A quarter is inserted in the slot of the cylinder or slot part, 2, Figure 127, and turned through 180° by means of the handle 1, then dropping into a cash box below. During this half-revolution, the coin serves as a connecting shaft between the buying handle and a 50-tooth gear wheel 3, mounted on the inside end of the slot part, and causes this wheel also to make a half-revolution. The 50-tooth wheel meshes through an intermediary wheel, or idler, 4, Figure 128, with a 20-tooth wheel, 2, (for gas sold at $1.00 per thousand) on the end of a threaded axle, 3, Figure 129, known as the carriage worm, and, therefore, this axle revolves fifty-twentieths of one half-revolution, or one and one-quarter revolutions. On the worm is mounted a 25-tooth gear wheel, 5, which is driven forward one and one-fourth threads; this wheel, known as the carriage wheel, being prevented from revolving with the carriage worm owing to the fact that the teeth on its periphery engage with the teeth of a pinion axle, 1, which is prevented from revolving at this time. As the carriage wheel is jacked forward, a frame,

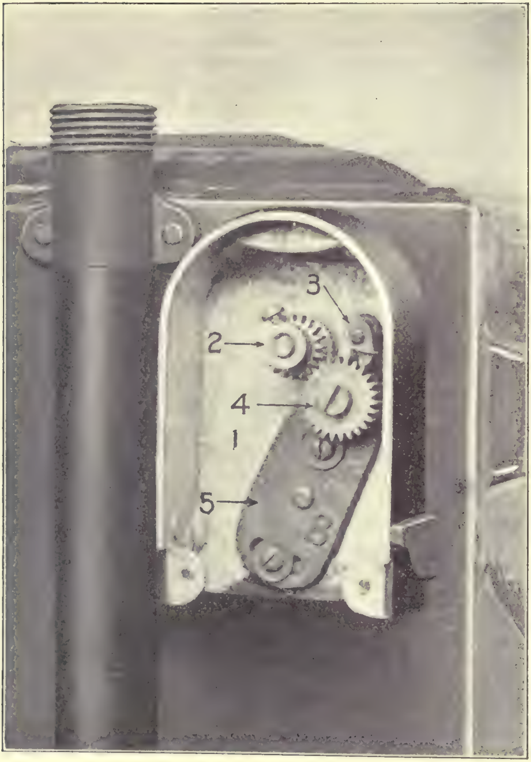


Figure 128.—Gear Box of Prepayment Meter, page 449.

1. Gear Box
2. Price Wheel and Set Screw
3. Click
4. Intermediary Wheel
5. Brass Swing

partly surrounding it and known as the carriage, is also moved forward; a projecting arm, 13, on the back end of the carriage lifting the prepayment valve 2 off its seat, and another arm, 4, on the front end moving the credit pointer forward. This completes the operation of buying gas by allowing it to enter the long channel through the opened prepayment valve and then to pass on through the meter in the usual manner.

The second purpose of the prepayment mechanism is to cut off the gas supply after the passage of a predetermined volume. With gas at $1.00 per thousand cubic feet, the predetermined volume is 250 cubic feet for each quarter used to operate the buying mechanism. The cutting off is accomplished as follows: The horizontal axle operating the index makes one revolution upon the passage of two cubic feet of gas. A spiral 8, mounted on this axle, engages the teeth of a 24-tooth gear wheel 9, secured to a long pinion axle, 1, having six teeth. One revolution of this pinion axle is made upon twenty-four revolutions of the horizontal axle and spiral, corresponding to the passage of 48 cubic feet through the meter. The teeth of the long pinion axle engage those of the 25-tooth carriage wheel 5, previously referred to, and cause it to revolve, and, in so doing, move back on the threaded axle on which it is mounted, the axle being prevented from turning at this time by means of a buffer or friction brake. Each tooth of the pinion axle has a value of 48 divided by 6, or 8 cubic feet. Each tooth of the carriage wheel will have the same value, so a complete revolution will correspond to the passage of 200 cubic feet. Two hundred and fifty cubic feet will mean one and one-fourth revolutions, or a motion of one and one-fourth threads on the threaded axle, with a corresponding movement of the carriage and a return of the prepayment valve and credit pointer to the original position from which they moved on the purchase of 250 cubic feet of gas.

A small dial on the meter front, called the credit dial, enables the consumer to know at all times how nearly used up is the supply of gas already paid for. A pointer, mounted on credit pointer shaft, 4, Figure 129, moves to the right from a starting

point as gas is bought, and backward as gas is used, so that proximity to the starting point indicates that the prepayment valve is preparing to close.

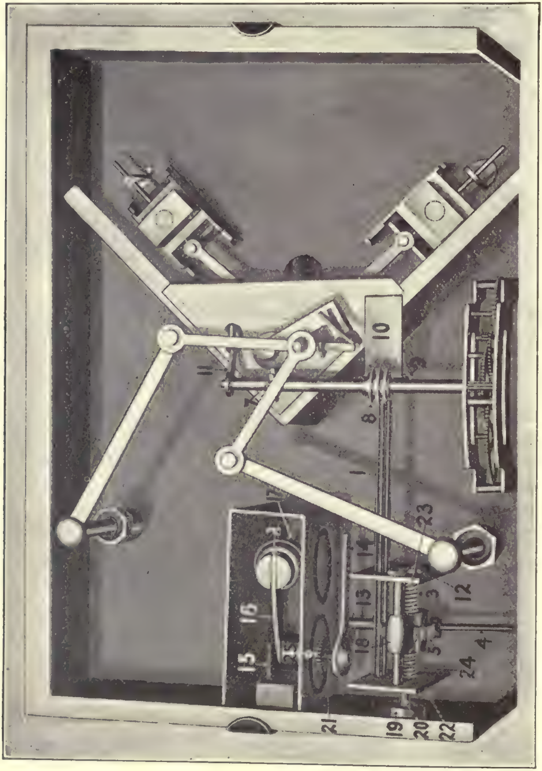


Figure 129.—Top View of Prepayment Meter, page 449.

1. Pinion Axle
2. Cut-off Valve
3. Carriage Worm
4. Credit Pointer Shaft
5. Carriage Wheel
6. Cut-off Valve Stuffing Box Cap
7. Horizontal Axle Wheel
8. Horizontal Spiral
9. Pinion Axle Wheel
10. Pinion Axle Rest
11. Horizontal Axle Rest
12. Stop on Carriage Worm
13. Carriage Pin
14. Outside Cut-off Valve Arm
15. Inside Cut-off Arm Brace
16. Inside Cut-off Arm
17. Cut-off Valve Seat
18. Carriage Bracket
19. Outside Stuffing Box
20. Stem for Price Wheel
21. Cut-off Valve Shaft
22. Left Hand Carriage Rest
23. Right Hand Carriage Rest
24. Carriage Bracket Guide
25. Cut-off Valve Stuffing Box

The gearing values of the different parts in the cutting-off mechanism, as above described, may be illustrated as follows:

$$\frac{A \times B \times D \times F}{C \times E \times G} = \text{cubic feet per quarter's worth.}$$

$$\frac{2 \times 24 \times 25 \times 50}{6 \times 20 \times 2} = 250$$

A = cubic feet per revolution of horizontal axle.
B = number of teeth in pinion axle wheel.
C = " " " " " "
D = " " " " carriage wheel.
E = " " " " price "
F = " " " " 50 wheel.
G = " " coins required to produce one revolution of the 50 wheel.

SECTION II

INSTALLATION AND MAINTENANCE

CHAPTER XLVIII

SIZES AND CONNECTIONS

Capacities and Dimensions

Owing to the great difference at present existing in the capacities of meters of the same nominal size, it is necessary for the gas engineer to provide a table of capacities based on a fair average of the meters of the same size owned by his company. As the result of exhaustive tests of the meters in use in Philadelphia, the average capacities shown in the table following have been adopted.

A comparison between this table and the standard advocated on page 414 will illustrate the truth that, advisable as is the proposed standard as a guide to the purchase of all new meters, economy enforces the use of the great variety of sizes purchased in former years and still in stock.

The letters "S" and "L" denote respectively "Small" and "Large". This division is required by the fact that, as shown, the capacities of the larger size meters vary greatly as between the different makes; so much so that the range of capacities of a given size sometimes overlaps into the range of the next size. By experiment, however, it has been found feasible to divide all of the meters for each size 100-lt. and over into the two classes mentioned. These meters have been badged correspondingly. Capacity badges have been placed by the manufacturers on the "A" meters, the large capacity 5-lt. and the 5-A meters purchased in recent years.

There are many instances in which a knowledge of outside dimensions is valuable in installation work, and, therefore, these dimensions are included in the following table.

Capacities and Maximum Outside Dimensions

Size of Meter	Capacity (Cu. ft. per hr.)	Height (Bottom to Top of Screws)	Width (Outside of Screws)	Depth (Front to Back)
3	65	$14\frac{3}{4}''$	$11\frac{1}{16}''$	$8\frac{1}{2}''$
5	90	$16\frac{1}{8}''$	$12\frac{7}{16}''$	$9\frac{5}{8}''$
5A	175	$16\frac{1}{8}''$	$12\frac{7}{16}''$	$9\frac{5}{8}''$
10	140	$17\frac{15}{16}''$	$14\frac{7}{16}''$	$11\frac{3}{8}''$
10A	375	$17\frac{15}{16}''$	$14\frac{7}{16}''$	$11\frac{3}{8}''$
20	200	$21\frac{15}{16}''$	$17\frac{7}{8}''$	$12\frac{3}{4}''$
30	280	$25\frac{1}{8}''$	$20\frac{3}{4}''$	$15\frac{3}{4}''$
30A	875	$25\frac{1}{8}''$	$20\frac{3}{4}''$	$15\frac{3}{4}''$
45	315	$28\frac{1}{2}''$	23 [illegible]''	$20''$
60	475	$33\frac{5}{16}''$	$26\frac{3}{4}''$	$20\frac{7}{8}''$
60A	1500	$33\frac{5}{16}''$	$26\frac{3}{4}''$	$20\frac{7}{8}''$
S–100	600	$36\frac{1}{8}''$	$31\frac{1}{8}''$	$24\frac{3}{4}''$
L–100	875	$36\frac{1}{8}''$	$31\frac{1}{8}''$	$24\frac{3}{4}''$
S–150	1015	$43\frac{3}{4}''$	$36\frac{7}{8}''$	$29''$
L–150	1350	$43\frac{3}{4}''$	$36\frac{7}{8}''$	$29''$
150A	3400	$43\frac{3}{4}''$	$36\frac{7}{8}''$	$29''$
S–200	1380	$43\frac{3}{4}''$	$42\frac{3}{4}''$	$29''$
L–200	1845	$43\frac{3}{4}''$	$42\frac{3}{4}''$	$29''$
S–300	1635	$57\frac{3}{8}''$	$54\frac{1}{2}''$	$43\frac{1}{4}''$
L–300	2270	$57\frac{3}{8}''$	$54\frac{1}{2}''$	$43\frac{1}{4}''$

Capacities are obtained with five-tenths loss of pressure through meter, and represent maximum work which the meter should be required to perform.

Schedules For Various Conditions

After having established a schedule of average capacities, it is evident that another schedule must be worked out to show the safe size of meter to supply gas for an estimated consumption, as based upon the number of burners or appliances on, and the nature of, the premises to be supplied. Gas companies ordinarily are not in a position to determine, with any degree of accuracy, the maximum rates of consumption of various consumers; consequently, the determination of the size of meter to be set in a specific case, is not usually an exact science. It is known, however, that the actual maximum demand is a small percentage of the total possible demand in all dwellings having no fuel appliances, and that there is a closer approximation of actual maximum demand to possible demand where fuel appliances are installed. (By possible demand is meant the demand that would result if each lighting burner and appliance connected to a meter were used to its fullest extent at the same time.) From this knowledge the following schedule was determined.

METERS FOR FUEL AND ILLUMINATION

Number of Burners	No Fuel Appliance		Ordinary Fuel Appliance	
	Size of Meter		Size of Meter	
	Lt.	"A"	Lt.	"A"
1–10	*3		*3	
11–20	*3		5	
21–30	5		5	
31–40	10	5	10	5
41–50	10	5	10	5
51–60	20	5	20	5
61–70	20	5	30	10
71–85	30	10	45	10
86–100	45	10	60	30
101–140	60	30	S–100	30
141–180	60	30	L–100	30
181–250	L–100	30	150	60
251–350	200	60	200	60
351–500	S–300	150	L–300	150
501–700		150		150

To determine a required meter size, the number of illuminating burners should be counted, and to this figure should be added the equivalent, in burners, of any fuel appliances or engines to be supplied. The total thus obtained should be compared with the "Number of Burners" column, and opposite the corresponding item will be found the meter size in its proper column.

*Only on existing connections; use 5-lt. for new sets.

Most companies still own too many 3-lt. meters to allow of a wholesale condemnation of this size, and the above schedule, temporarily changed as stock conditions demanded to require use of 3-lt. for new sets in small dwellings, has kept in service in one large situation, all 3-lt. meters owned and still amounting to 5 per cent of the total meter stock.

When the demand in a dwelling exceeds the capacity of a 45-lt., and there is no surplus stock of old meters 60-lt. and larger, it is good practice to set an "A" meter, and thus obtain a large hourly capacity without the large case dimensions so often objected to by householders.

For convenience, the demand in the schedule is expressed as so many 5-ft. burners. This involves the valuation, in burners, of the consumption of various appliances. Some valuations belonging in such a table are given below:

	*Equivalent in Burners
Broilers (per compartment)	5
Cake Griddles (per burner)	2

	*Equivalent in Burners
Cigar Lighters	1
Confectioners' Stoves	30
Curling Iron Heaters	1
Gas Engines (per h. p.)	4
Gas Grate	10
Gas Log	10
Heating Stoves, Round	5
Heating Stoves, Radiators (per tube)	1
" " Reflectors	8
Hot plates, 1-burner	4
" " 2-burner	6
" " 3-burner	9
Laundry Hot Plates	10
Laundry Iron Stove (per mixer)	2
Oyster Cookers, 15-inch	12
" " 30-inch	24
" " 45-inch	36
Ranges, Ordinary, cabinet or elevated oven (1 set oven burners)	18
" Cabinet or elevated oven (2 sets oven burners)	24
" Hotel (per section)	50
" Large Cabinet	35
Sad Irons, Domestic	1
" " Pressing	2
Soldering Furnaces (per mixer)	3
Water Heaters, Circulating,	8

*One burner equals five cubic feet per hour.

Thus far the discussion has concerned locations where the meter would supply gas for a variety of uses, and with an imperfectly known load factor. With the increasing demand for gas in engines and industrial work generally, there are now many instances where a meter supplies only one appliance or a group of similar appliances. This enables a direct determination of the meter capacity for each location, and avoids the generalizations involved in any schedule. The meter chosen should be never smaller than one able, with a 0.5 inch loss, to supply the maximum possible demand. If the use of gas at the maximum rate will be continuous throughout the working day, one authority believes that a 50 per cent excess meter capacity should be provided to prevent the excessive wear that would result from a continuous delivery at maximum capacity.

Gas engines are so frequently met with, and their gas requirements are so strictly proportional to size, that it is both feasible and convenient to devise a meter schedule applicable to most installations. Such a one, applying only when the engine is

supplied through a separate meter, is given below. It is based on the assumption that the usual storage governing device forming part of the engine supply line, will so equalize the pull on the meter that the intermittent and almost instantaneous demand for gas when the intake valve is open, will never involve a delivery by the meter for any length of time at a rate greatly in excess of the average hourly demand of 20 cubic feet per horsepower hour; also, that no gas engine is working at full load continuously.

Meters for Gas Engines

Engine	Size of Meter	
H. P.	Lt.	"A"
1–3	5	
4–5	10	5
6–7	20	5
8–11	30	10
12–14	45	10
15–20	60	30
21–25	S–100	30
26–40	L–100	30
41–50	S–150	60

Connections

Piping

The piping between the house end of the service and the meter inlet, and from the meter outlet to the house piping generally is known as "connection piping" or "meter connection piping." It now is, invariably, of iron pipe, excepting for "meter connection" proper as noted hereafter. It generally is installed when the first meter is set. The size of the pipe is based upon the probable demand for gas and, therefore, upon the size of the service and of the meter, but the expense of changing this pipe is so slight, as compared to a service renewal, that the minimum size may well be 1 inch instead of 1¼-inch as for services. Also, the length of this piping being so much greater than that of the meter screws and tailpieces, its diameter must be correspondingly larger in order not to restrict unduly a flow of gas within the meter capacity. The schedule on page 460 results from an observance of the above principles.

No mention is made of the piping between the meter outlet and the house piping. This always is short, never is smaller than the piping from the service, and often is the size of the house piping to which it joins.

METER CONNECTIONS

Meter		Iron Pipe between Service and Meter Cock	Meter Cock	Tailpiece of Meter Union	
Lt.	"A"			Lt.	"A"
3		1"	$\frac{3}{4}$"	$\frac{3}{8}$"	
5		1"	$\frac{3}{4}$"	$\frac{1}{2}$"	
10	5	1"	$\frac{3}{4}$"	$\frac{3}{4}$"	$\frac{1}{2}$"
20	5	$1\frac{1}{4}$"	1"	1"	$\frac{1}{2}$"
30	10	$1\frac{1}{4}$"	$1\frac{1}{4}$"	$1\frac{1}{4}$"	$\frac{3}{4}$"
45	10	$1\frac{1}{2}$"	$1\frac{1}{2}$"	$1\frac{1}{2}$"	$\frac{3}{4}$"
60	30	$1\frac{1}{2}$"	$1\frac{1}{2}$"	$1\frac{1}{2}$"	$1\frac{1}{4}$"
100	30	2"	2"	2"	$1\frac{1}{4}$"
150	60	$2\frac{1}{2}$"	*$2\frac{1}{2}$"	$2\frac{1}{2}$"	$1\frac{1}{2}$"
200	60	$2\frac{1}{2}$"	*$2\frac{1}{2}$"	$2\frac{1}{2}$"	$1\frac{1}{2}$"
300	150	4"	*4"	°4"	$2\frac{1}{2}$"

*Double gate valve with wheel handles and screw ends.
°Flanged connections.

All of the above piping should be secured, where necessary, to vertical walls, and suspended from ceilings at sufficient points to take all strains from the meter.

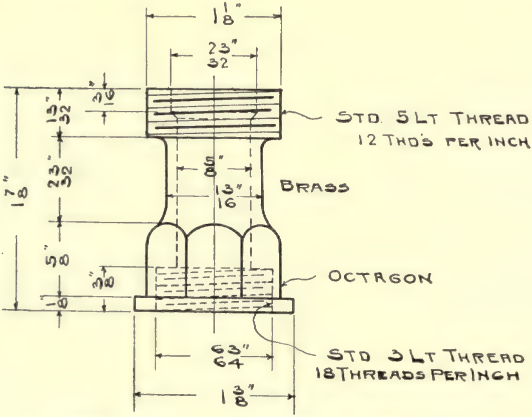


Figure 130.—Three to Five-light Adapter, page 461.

Many companies, in order to utilize their existing meter stock, set, at times, meters larger or smaller than called for by their standard schedule. The most frequent case of this kind is the use of 3-lt. meters in place of 5-lt. As the usual expectation is that at some future date all the 3-lt. meters will have been condemned, the adapter, Figure 130, is recommended, for, by enabling the use of 5-lt. connections with a 3-lt. meter, it makes possible the gradual substitution of 5-lt. meters without a double cost for connections. The length of the adapter is equal to the excess in height of a 5-lt. over a 3-lt., so there need be no change in the position of the meter shelf.

Other more or less temporary use of nonstandard sizes should be governed by the same general thought of using the *connections* that are considered to be permanent, and making a temporary size change at the meter screw.

Lead

Gas meters came into use before there was a plentiful or cheap supply of small iron pipe and fittings. Lead pipe consequently reigned supreme for gas as well as water work, being used not only for connecting the meter to house piping and to service pipe, but also for the service pipe itself.

In many ways, lead is admirably adapted to furnish the junction between rigid iron piping and the box, made up of tinned iron plates soldered together, that forms the meter. As, even today, with more thought given to meter screw design and with the iron connections carefully arranged to afford all requisite play, there are many leaks resulting from strained screws, it is clear that the early use of the ductile lead removed many difficulties that otherwise would have confronted the meter setter of those days.

The same softness and readiness to assume a new shape which made lead advantageous as a material for connecting meters, proved also one of its disadvantages. Undesirable kinks, interfering more or less completely with gas flow, were far too frequent with lead. One particularly bad feature was that often the stoppage was not sufficient to make the consumer attribute to any such cause, the poor light he was getting. The tendency to kinking was often aggravated (unnecessarily so, after iron pipe became common except for "meter connections") by an undue length of lead connection, especially if this was true, not only absolutely, but also relatively to the space to

be bridged. Two causes that tended to this lavish and unfortunate use of lead were, first, lack of planning in relating the service to the house piping, and, second, the fact that as the meter connection was usually installed by a plumber and paid for by the consumer, there was no incentive to economy of material.

The assumption by the company of the cost and work of meter connection assured in the end a proper and economical design. The over-all length of lead pipe for connections 10-lt. and under was limited to 12 inches, and to 15 inches for 20 to 60-lt. Such connections, for a 5-lt. meter, are illustrated in Figure 131, the over-all length of lead used being the same in each case. That some form of iron connection is to be preferred even to this correct design, is due to the greater resulting economy and convenience, rather than to any inherent objection to lead from a physical standpoint, for no such objection exists, aside from the very small chance that its low melting point might, in some fires, be the determining cause of an early escape of gas from a lead connection and thus produce damage otherwise avoidable.

The thickness of the lead pipe never has been standardized. A few companies followed the practice of supporting the meters from the connections, and, therefore, generally used a heavy pipe. This likely was true also of the plumbers. Probably the majority of the connections were of "extra light" pipe. The table below is taken from the report of the Committee on Meter Connections in the 1915 Proceedings of the American Gas Institute, in which will be found much detail about modern connection practice:

Weights per foot of Lead Pipe

Size			Weight of Pipe		
Meter lt.	Lead Pipe	Cock	Medium lb. oz.	Light lb. oz.	Extra Light lb. oz.
3	$\frac{5}{8}''$	$\frac{3}{4}''$	2 –	1 12	1 4
5	$\frac{3}{4}''$	$\frac{3}{4}''$	2 8	2 –	1 8
10	1''	1''	3 4	2 8	2 –
20	$1\frac{1}{4}''$	$1\frac{1}{4}''$	3 12	3 –	2 8
30	$1\frac{1}{2}''$	$1\frac{1}{2}''$	5 –	4 –	3 8
45 to 60	$1\frac{3}{4}''$	$1\frac{1}{2}''$	5 8	4 8	3 12

When using two lead connections, the piping is run both ways to the meter, measurements being taken carefully enough, so that the final adjustment necessary to make the lower end of

the tailpiece face truly with the top of the meter screw, can be effected by a slight bend in one or both of the connections.

Iron and Lead

One of the first steps in the evolution from lead to iron, was the use of an iron inlet and a lead outlet connection. Such an inlet connection for a 5-lt. meter is shown in Figure 132. The outlet connection would be the one in Figure 131. This combination of iron and lead furnishes a very satisfactory connection for meters 10-lt. and smaller, has been used by the thousands, and, until recent years, could be considered best practice. In joining it to the connection piping, which is run

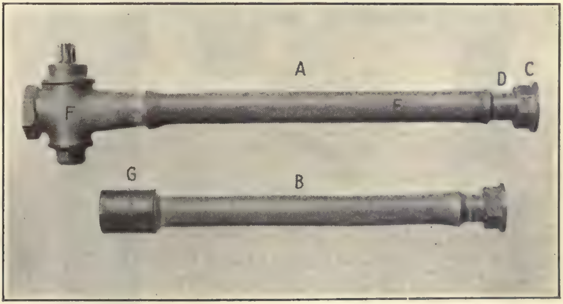


Figure 131.—Lead Meter Connections, page 463: A, Inlet Connection; B, Outlet Connection; C, Cap; D, Tailpiece; E, Lead Pipe; F, Meter Cock; G, Coupling.

in the same way as for two lead connections, the swing joints give the adjustments necessary on the inlet side, and the lead pipe those on the outlet side.

All-Iron

For a long time, iron piping generally has been used on meters larger than 10-lt., for both inlet and outlet connections, and by some companies, for all sizes. The inlet connection might be as shown in Figure 132, and the outlet connection of varying combinations of pipe and fittings. The objection to all-iron for the smaller meters was that the lack of care used by the aver-

age meter setter was sufficient, in the absence of at least one lead connection, to cause too many strained meter screws and column seams.

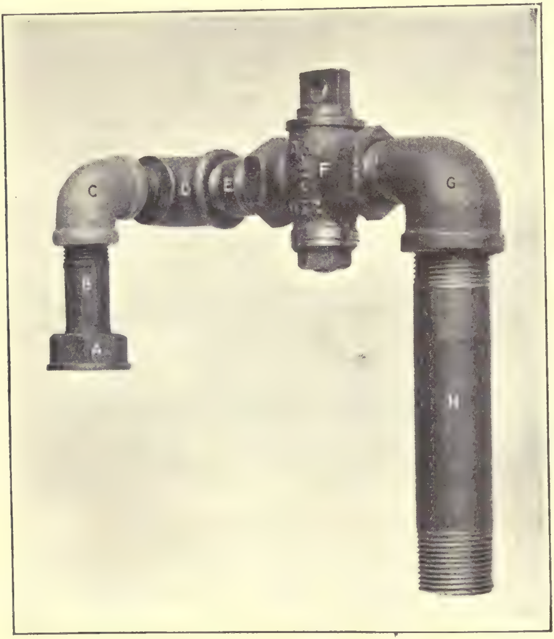


Figure 132.—Iron Inlet Connections, page 463: A, Cap; B, Tailpiece; C, ½″ Ell; D, ¾″ x ½″ Service Ell; E, ¾″ Nipple; F, ¾″ Brass Meter Cock; G, 1″ x ¾″ Service Ell; H, 1″ Nipple.

For the larger meters, however, accepted practice involves all-iron connections. For meters without flanges, Figure 133 illustrates, in a single line sketch, the fittings used for a 10-lt.

meter, and Figure 134 shows two views of the inlet piping of a flanged connection.

In all of the iron connections shown, it will be noted that there are a number of swing joints. This is to enable movement in various directions and thus to avoid the necessity for bringing any strain on the meter screws. There is room for much difference of opinion as to just how many swing joints really are called for in each form of connection. They are of especial use with a flanged connection, as to avoid any strain on the meter, each pair of flanges should face up accurately, with perfect registration of corresponding bolt holes. The difficulty is increased by the fact of the large pipe—4-inch or greater—required. The inlet connection usually is made first. On page 414, it already has been noted how the use of the "A" meter enables the avoidance of any flanged connections.

Coupled or Tie-In

While the iron inlet and lead outlet, as used for the smaller meters, formed an advance on previous practice, nevertheless the leaks that could be traced to connection strains were numerous enough to warrant further experiments, and, as a result, various forms of connections have been developed, based on coupling together or tying in the two connection sides. These connections fall into two classes, according to whether the crossbar is in one piece and therefore rigid, or in two or more pieces and therefore capable of adjustment. The rigid type has been used to a considerable extent, always in conjunction with offset tailpieces, but does not afford the necessary adjustments to insure the absence of strains on the meter screws under all conditions. A satisfactory form of the adjustable type is shown in Figure 135. The curved washers, or rocker plates, sliding in the beveled grooves, permit adjustment of the two malleable iron members in every direction, making the connection a universal joint, so that no strain need be thrown on the meter screws. Figure 136 shows the connection in place on a 5-lt. prepayment meter. It will be seen how positive, and yet readily adjustable, is the support given the meter by the hanger rods and the board strip. The relation of the connection to the inlet and outlet piping is shown in Figure 137.

In setting a meter on this connection, first the tailpieces are screwed into the connection; then the bolts are loosened, the tailpieces placed on the meter screws, and the caps made up

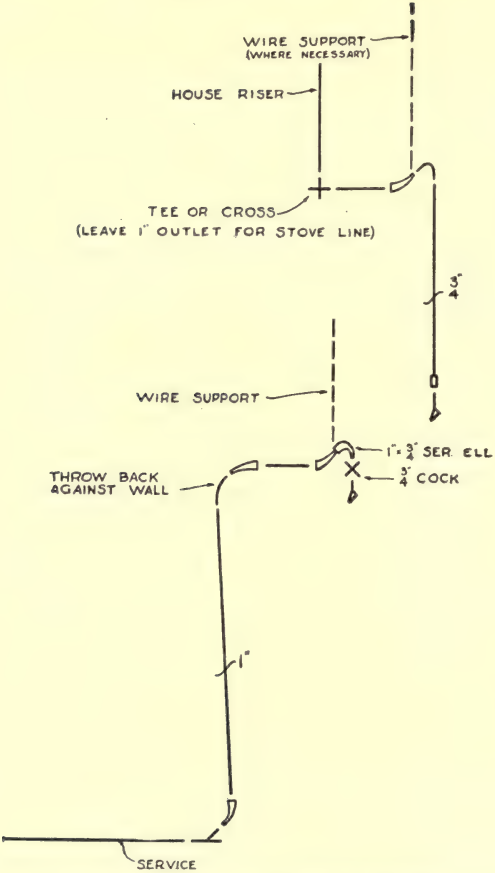


Figure 133.—All-Iron Connections, page 464.

hand tight. (See Figure 136.) Thus tight joints, with no strains, are assured, and the two parts of the connection assume the correct position for bolting together. When this bolting is completed, the connection is unscrewed from the meter and then joined to the inlet piping. The outlet piping is built up from the house piping to the union on the connection. The connection being thus joined to the piping, and the latter prevented by wire supports from sagging, the meter can once more be connected to the tailpieces, with full assurance that its screws and columns are under no strains. The last operation is to place the hangers

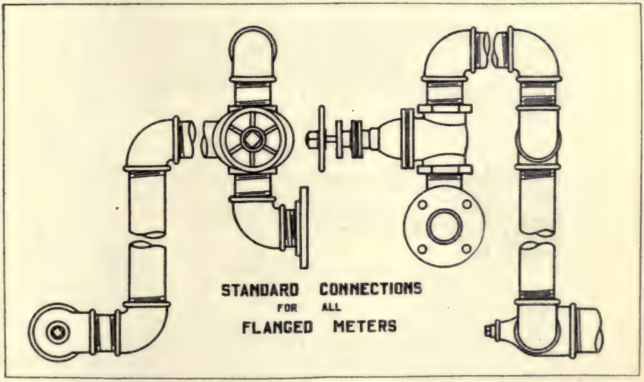


Figure 134.—All-Iron Connections with Flanges at Meter, page 465.

and shelf in position and screw up the hanger nuts until the weight is taken by the shelf.

A variation of the coupling idea is shown in Figure 138, which illustrates a method of tying together the vertical inlet and outlet piping. Only one special fitting, A, is required. The especial advantage it offers is that it can be adjusted in place for any meter size. It also supports the house riser directly on the service. The sliding shelf will be noted as extending from the inlet piping.

Figure 139 is a still more recent adjustable connection, based on the same principle of rigidly joining the inlet and outlet connection piping. After thorough consideration, it has been

approved for trial on a large scale, both for single meters and for header work, as being superior to any other connection now available. Its advantage may be thus summarized: Universal adjustment; convenient location of meter cock; availability for large meters; substantial support for meter in position

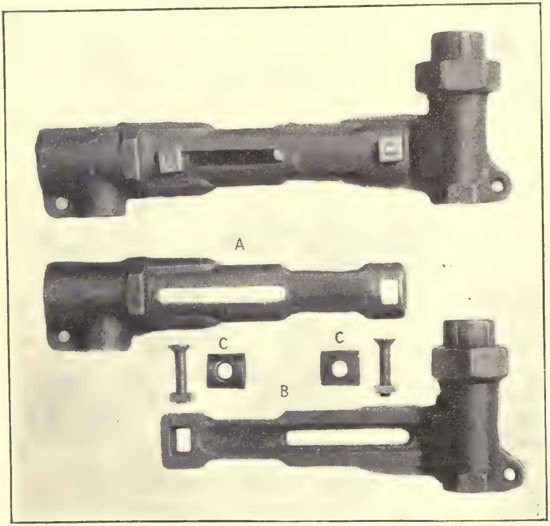


Figure 135.—Adjustable Tie-in Connections, page 465: A, Inlet Member; B, Outlet Member; C, Rocker Plates.

away from wall; only one special fitting (the service tee with solid male end); ability of installation by relatively unskilled labor, for all of it, except the ells, cocks and tailpieces, may be run at any time after the service and house piping are completed. The wires from which the shelf rods are supported, are bought with the eye already made, and are twisted in place around the ells after the connection is finished. This connection will be used on meters up to 60-lt. or 60-A inclusive, and, therefore,

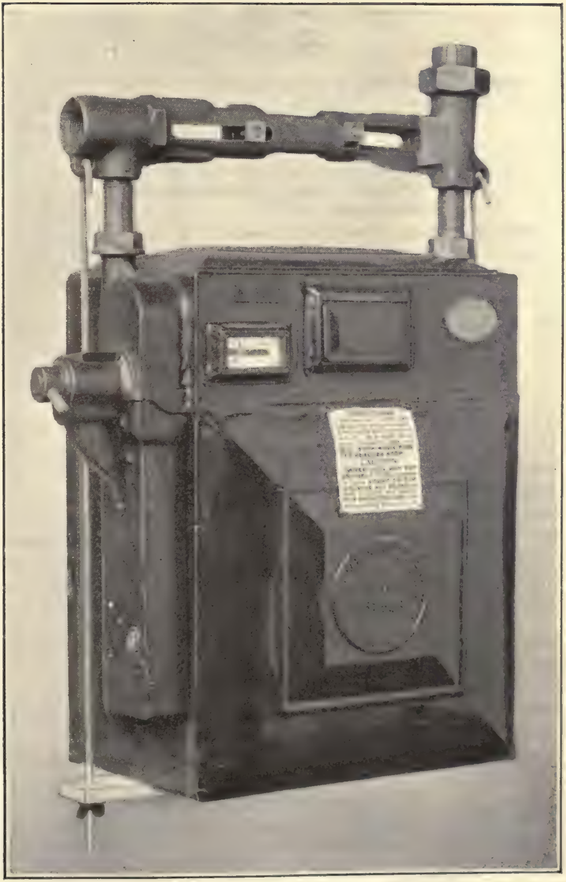


Figure 136.—Adjustable Tie-in Connections on Five-light Prepayment Meter, page 465.

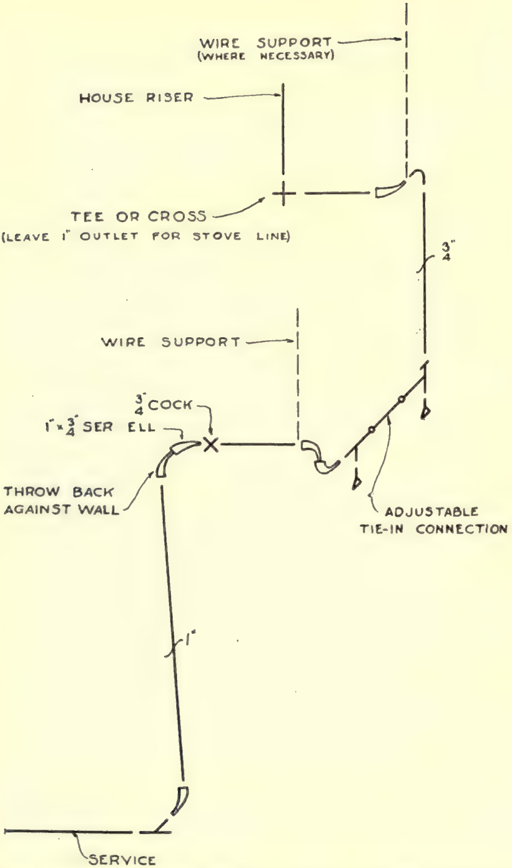


Figure 137.—Adjustable Tie-in Connections with Adjacent Piping, page 465.

will care for all sizes ordinarily supported by shelves attached to walls.

Welded

The perfection of welding methods has made comparatively easy the welding into one piece of any meter connection, no matter how complicated. The advocates of this new departure for connection work are enthusiastic about it, but so far, impartial opinion is not willing to consider welding except where large piping is used, or there is intricate "header" work involving many joints.

Before closing this account of the various methods which have been used for connecting meters, it perhaps should be said that at any one time, the average company would have in use, under the same conditions, two or more types, each representing an improvement, real or supposed, over the preceding type, but no one of them possessing sufficient advantages to warrant a wholesale change of existing connections.

Headers

So far our descriptions have referred to the installation of one meter only. Where there are many apartment houses, especially if the company requires that all meters be near the head of the service, batteries of closely assembled meters will be required. Space always is at a premium, and, therefore, the best connection design embodies the minimum of piping compatible with assessibility and absence of strain. Figure 140 illustrates the use of an adjustable tie-in connection on header work. Figure 141 shows the practice for larger meters with no tie-in connection. Lead should never be used for header work.

Except where piping larger than 2-inch is involved, and the ultimate demand for gas is known at the time of header installation, it is advisable to maintain the size of the common inlet pipe uniform through its entire length. In some sizes, economy will prescribe the connection of the gas supply to the midpoint of this inlet pipe

Cocks

Location and Number

The illustrations show a cock on the inlet connection, and the schedule of meter connections on page 460 includes cock sizes also. The usual location is, as shown, near the meter, and in the smaller sizes, this allows the use, almost to the meter itself, of the large piping,—large in comparison with the meter screws,—

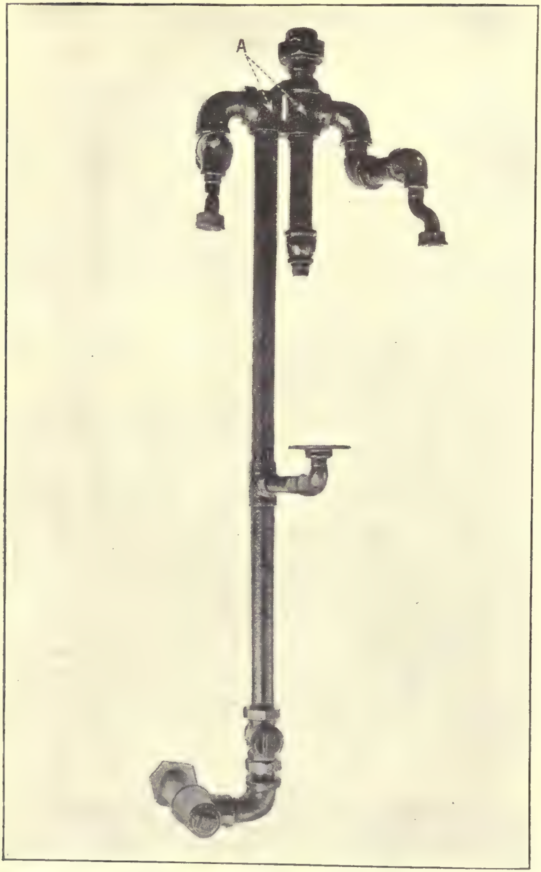


Figure 138.—Connection Joining Inlet and Outlet Piping—Meter Support on Inlet Piping, page 467.

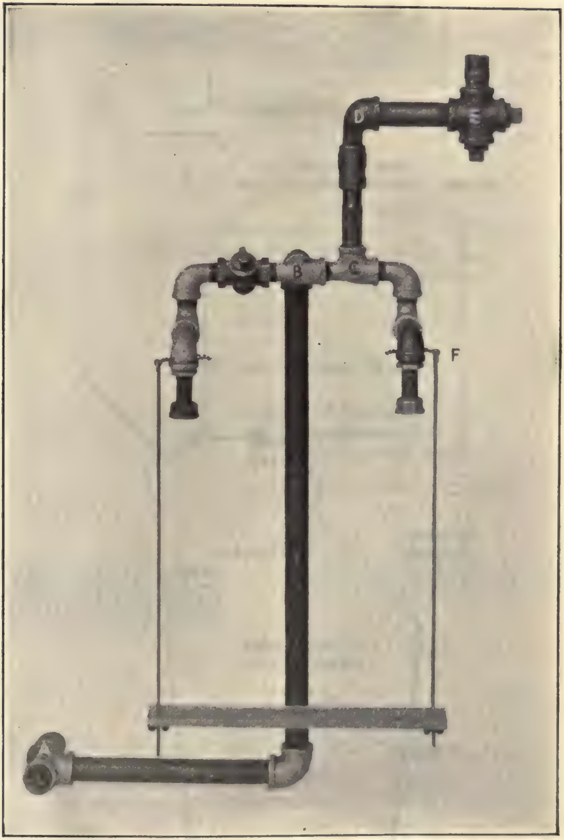


Figure 139.—Five-light Connection Joining Inlet and Outlet Piping—Meter Support from Connection, page 467: A, $1\frac{1}{4}''$ x $\frac{3}{4}''$ x $1''$ Tee on Service End; B, $\frac{3}{4}''$ Service Tee; C, $\frac{3}{4}''$ Special Service Tee with Solid Male End; D, $\frac{3}{4}''$ x $1''$ Service Ell; E, Bottom of House Riser; F, Wire Hanger Eye.

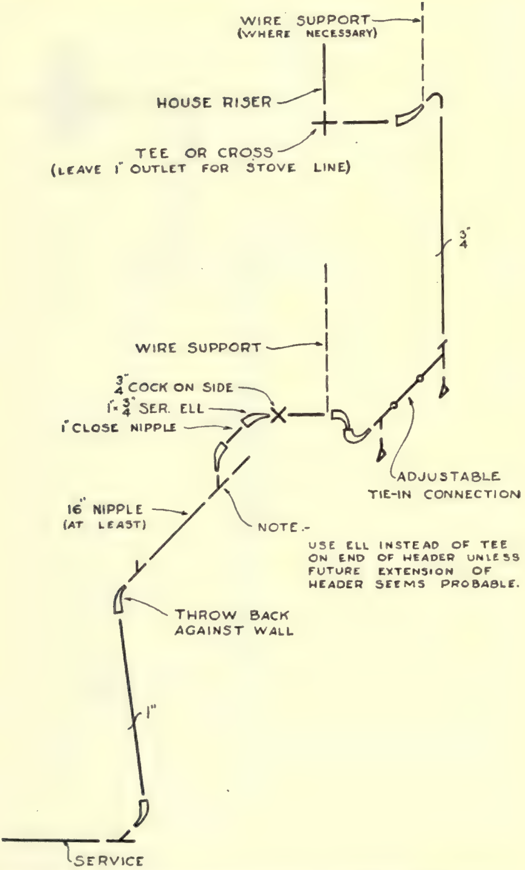


Figure 140.—Adjustable Tie-in Header Connections, page 471.

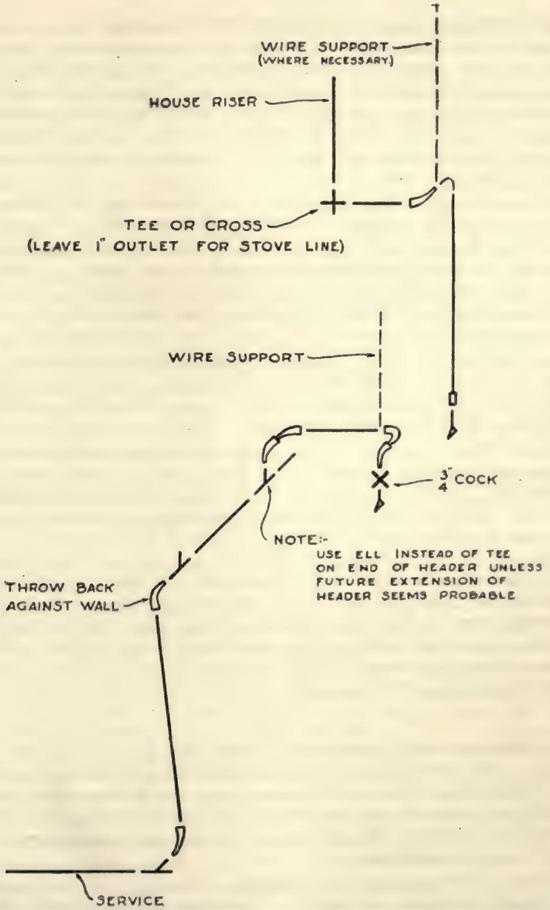


Figure 141.—All-Iron Header Connections, page 471.

called for by the schedule, without also entailing the expense of a cock of the same size. For better explanation, suppose that the company using the schedule on page 460 placed the meter cock at the bottom of the inlet riser (see Figure 101, page 378); this would require a 1-inch size for meters 10-lt. or smaller, instead of the $\frac{3}{4}$-inch size used when the cock is placed close to the tailpiece, which, for the sizes considered, never is larger than $\frac{3}{4}$-inch.

An advantage of this location at the service end is that a cock at that point controls all of the piping inside of the house, but the great majority of gas engineers do not view it with favor, especially if there is also a curb cock in use (see pages 91 and 98). The absence of the latter may be considered as furnishing somewhat more reason for placing the meter cock at the service end, and in some situations using no curb cock, two inside cocks are placed: one, the meter cock, close to the meter, and the other, at the service end. However, this extra expense cannot be justified in view of the many companies operating satisfactorily with no curb cock and only the usual meter cock.

When more than one meter large enough to require an inlet valve supplies the same system of piping, each outlet connection should be equipped with a valve. Since the wheel handle of a valve, unlike the head of a plug cock, does not indicate by its position whether the valve is open or shut, a $\frac{1}{8}$-inch hole should be tapped in the piping between the valve and the meter outlet. This affords an opportunity, after both the inlet and the outlet valve have been supposedly closed, to make sure, by removing the plug, that all gas pressure is off the meter before starting to disconnect it. Such a hole also should be tapped on each outlet connection large enough to require a valve, where there is a by-pass around the meter.

Kinds

Considering only cocks used with iron pipe, there are two types: the "double-hex," A, Figure 142, and the union cock, B. The latter is more expensive than the former and has no excuse for being except when used at the service end location. Close to the meter, the union of the meter screw renders any other union superfluous.

There are two principal shapes of heads, viz., the square, D, Figure 142, and the flat, C. The latter economizes in metal, and is to be preferred. Companies supplying many apartment

houses, or with meters in other locations where gas might be turned on by consumers with dishonest intentions, use the wing lock cock, E, for meters out of use but left in place. This cock is, of course, appreciably more expensive than the plain cock, which fact has led at least one company having comparatively few services supplying more than one meter, to insert a solid tailpiece in the inlet connection of each meter shut-off, where, because of other meters supplied by the same service, the curb cock could not be closed.

In the preceding remarks, the word "cock" has been used to designate any form of stop, whether cock or valve. The schedule of meter connections on page 460 calls for a valve on meters 150-lt. and larger and 60-A and larger, because in sizes larger than 2-inch a plug cock is too apt to leak or not turn easily.

Material

As for service cocks, brass has been, until quite recently, the exclusively used material for meter cocks. Its recent tremendous advance in price is hastening the substitution of a cock having an iron body and brass plug. This generally means a slightly heavier and larger cock, size for size.

Detailed drawings, with other information about all-brass meter cocks, will be found on pages 284 to 291, inclusive, of the 1915 Proceedings of the American Gas Institute.

By-pass

The increasing industrial uses for gas have brought a class of consumers to whom a stoppage of supply for more than a few moments, would involve great inconvenience or monetary loss, and who, therefore, should be protected against such happening. Linotype machines in newspaper offices, industrial appliances for continuous processes, and many gas engines belong in this class. The only unintentional interruption of supply threatening a one-meter installation, is a "won't pass gas". There are, however, a number of occasions when it is desirable, from the gas company's standpoint, to shut-off gas from a meter during working hours, as, for instance, to change meters, or to make certain meter tests in place. If this work also involves the nonuse of gas by the consumer, experience indicates that the expense entailed in arranging for the work at a time to suit the consumer's convenience, or if this is not possible, the annoyance to the latter by the stoppage of his supply, justifies a far wider adoption, than now prevalent, of some remedy. Two remedies are avail-

able: a by-pass around the meter, or meters in parallel. The latter involves more meter investment and the possibility of poor

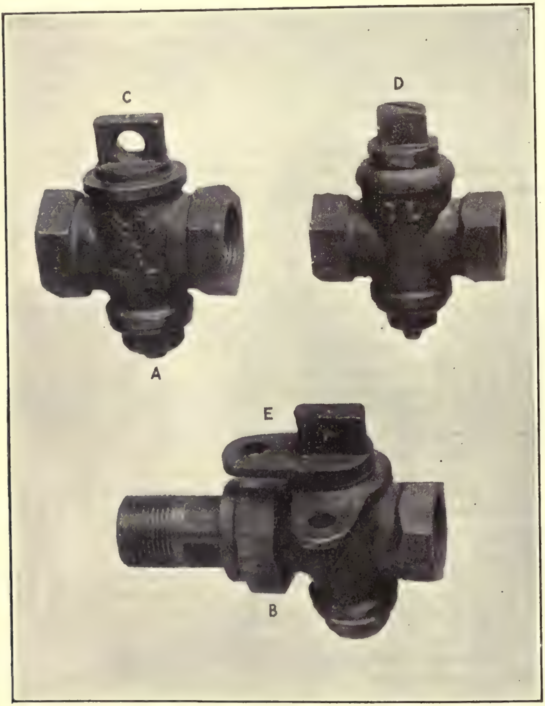


Figure 142.—Meter Cocks, page 476: A, $\frac{3}{4}''$ Double Hex; B, $\frac{3}{4}''$ Union; C, Flat Head; D, $\frac{1}{2}''$ Square Head; E, Lock Wing Head.

service from overload conditions, pending change of the disabled meter. To the by-pass, the only objection is its possible surreptitious use. This is not likely in any event by the class

of consumer needing the by-pass, and can be adequately safeguarded through the installation of a sealed stop on the by-pass. If the by-pass is put into use by the consumer, he at once notifies the company, which changes the meter as soon as possible. The gas used through the by-pass in the meantime is determined by estimate. Any gas so used during company work usually would be so slight as not to warrant any charge.

In addition to the stop on the by-pass and the inlet, one will be needed on the outlet piping, to permit supply through the by-pass in the absence of the meter.

Washer

Leaving out of consideration leaks in the meter case itself, the great source of meter leaks always has been the washer joint between the shoulder on the tailpiece and the face of the meter screw. Most of the leaks occurred after a year of service, being due to the drying out and consequent shrinkage of the universally used leather washer. Probably this has been more or less well known, even to those companies who have not made a careful record and study of these leaks. It became very apparent in Philadelphia fifteen years ago, after two years of data were available. The subsequent history of the attempts to overcome the trouble is considered to be of sufficient general interest to be sketched here.

Following common practice, the washer in use was whatever the supplier chose to send, and no attention had been paid to uniformity in dimensions or quality of the material, which usually was punched from miscellaneous scrap. Investigation revealed ten different qualities in one shipment. In the attempt to reach a standard, specifications were prepared calling for selected close-grained, smooth-faced calfskin, for exact dimensions as to thickness and diameters, and for clean-cut edges. Later on, it was decided that if each washer was of a uniform thickness, sufficient to cushion properly in unions of uneven facing, it was immaterial whether such thickness was the same for all washers of the same diameter. In the purchase of these selected leather washers, quality always was considered before price. Nevertheless, after three years and the use of several hundred thousand washers, the leak record showed that no real improvement had been effected, for the good leather shrank as badly as the poor had. Equally unsuccessful was an experiment with two hundred oil-soaked washers.

Soon after the first thought of a standard for leather washers, the idea of using lead was suggested, and this material, one-thirty-second of an inch in thickness, was used for 3 and 5-lt. connections for five years, following upon favorable results from a year's test of 1000 experimental installations. It was believed that tight joints would result from the use of a moistureless material, and that most of the extra first cost would be recouped through the re-use of washers. Experience showed that there was no saving in the quantity of washers bought, and that, per meter in service, the washer leaks doubled. The lead washers possessed no resilient qualities, and so were gradually flattened out by the vibrations of the meters and their connections until leaks resulted. Again, in order to obtain a tight joint, when the screw and tailpiece did not face exactly, it was necessary, in compressing the lead washer, to exert an undue strain on the screws and columns. Therefore, lead was abandoned in favor of selected leather, with the results above described.

Previous to using lead, several hundred pure rubber and also rubber-coated fabric washers, were installed, and examined with discouraging results after six months use. Other materials considered and discarded, were cardboard, from tarred and untarred rope, flaxboard, asbestos-, horn-, and star-fibre, leatheroid and glazed leathers.

As before stated, the results from selected leather, while better than those from lead, were not considered satisfactory, so in 1915, after a favorable experience elsewhere on a small scale, "ebonite" was substituted for leather on meters 10-lt. and smaller, and later on, for all sizes. To date, the indications are that this nonshrinkable washer will be no more expensive than selected leather, will retain its resiliency for years, even when exposed to the atmosphere, and will form tight joints, even on poorly-faced unions, without over straining the old type meter screws. This washer is made to fit snugly over the lip of the tailpiece, and this feature saves both time and washers. Under compression in the joint, the ebonite takes a set, and, therefore, should not be taken from one union for use in another, and only, after examination, made up again in the first union.

It will be several years before the ebonite washers in Philadelphia form a sufficient percentage of the total number to warrant any deduction from the leak records. In the meantime, it is safe to say that it will continue to be preferred to leather for its other qualities, even though the leak record is not greatly improved.

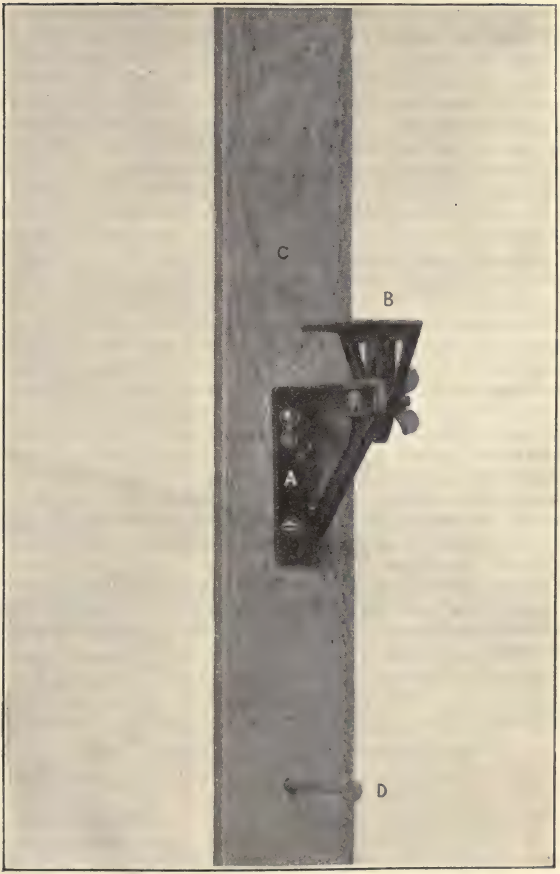


Figure 143.—Adjustable Meter Shelf, page 482: A, Shelf; B, Bracket; C, Back Board; D, 40-penny Wire Nail.

Support

An adequate support for the meter is an essential part of any properly executed connection job. In describing lead connections, it was stated that, in some instances, the meter was supported from the connection. However, this practice never was widely accepted. On the other hand, the tie-in connections offer as one of their peculiar advantages, a very satisfactory support of the small meter from the connection. Nevertheless, until these connections supersede the millions of ordinary connections still in use, methods of supporting the meter independent of the connection will be in demand. For sizes to 60-lt. inclusive, an adjustable shelf, or shelves, as shown in Figure 143, is satisfactory, though care must be used always in fastening the back board securely to the wall and relating the iron support to the meter bottom. Because of better possibilities of adjustment, it is superior to the shelf with a grooved back board in which is fastened two rigid metal wings. Numerous inspections of such shelves have revealed many meters either entirely unsupported or resting only on one point of a wing. Such lack of support invariably entails strains and leaks.

The wooden shelf, with triangular sides, an l back and bottom both rectangular, and the former extending above the latter,—probably the earliest type of shelf used,—was long ago condemned, because it enclosed the meter sufficiently to prevent free air circulation, and resulted in increased corrosion of meter backs and bottoms.

For sizes larger than 60-lt., support should be given by wooden or metal stands resting on the floor, by wire or other supports pendant from the ceiling, or, more rarely, by brackets attached to a wall.

CHAPTER XLIX

EXECUTION OF METER ORDERS

General Organization Details

Chapter II contains a paragraph describing the skeleton of the organization requisite for fitting work. As stated there, this organization would care for "all work done inside of buildings, this including complaints and all branches of fuel and lighting appliance work." At this point will be described only the conditions under which *meter fitting* work is done. A similiar description of appliance and complaint work will be given later on when treating of these branches of distribution activities.

Meter-fitting work naturally falls into two classes, according as there is, or is not, a meter to be carried. The first class comprises setting, changing and removing meters. The great bulk of such work is done from specially constructed covered wagons (see Figure 74, page 209). The meters are secured by separate straps to padded shelves on each side, while the tools and connection material are carried in bins on the wagon bottom. Whether there should be a fitter, or a fitter and helper (the latter then acting as driver), on each wagon, should be determined mainly by the relative economy of the two arrangements. Where the work is intricate, usually two men are preferable. Each wagon leaves the shop supplied, if possible, with orders sufficient for a day's work, thus saving the time that would be required in returning to the shop for more work.

A standard equipment of a meter wagon would be as follows:

Tool Equipment of Ordinary Meter Wagon

1 $\frac{3}{8}$-inch Bit,
1 $1\frac{1}{4}$-inch "
1 Stationery Box,
1 Ratchet Brace,
1-gallon Alcohol Can,

1 "Dope" Can and Brush, } in box,
1 Squirt Oil Can, }
1 Soap Can and Brush,
1 Small Meter Test Cap and Case, 3 to 20-lt. inclusive (Figure 59, page 187),
1 Large Meter Test Cap and Case, 30 to 100-lt. inclusive (Figure 59),
1 $\frac{3}{4}$-inch Cold Chisel, 6 inches long (E, Figure 26, page 136),
1 $\frac{7}{8}$-inch Plugging Chisel, 10 inches long,
1 $\frac{3}{4}$-inch Wall Chisel (B, Figure 62, page 192),
1 $\frac{1}{2}$-inch Wood Chisel (A, Figure 62),
1 Stop Box Cleaner (spoon),
1 No. 1 3-wheel Pipe Cutter,
1 No. 2 " " "
1 Safety Device for cleaning service (Figure 69, page 202),
1 6-inch Screw Driver,
1 12-inch Bastard File,
1 $1\frac{1}{2}$-lb. Ball Pein Machinist's Hammer,
1 Extra Heavy Stop Cock Key (for stiff stop cocks),
1 Long Stop Cock Key (standard), (B, Figure 45, page 168),
1 Asphyxiation Kit (C, Figure 57, page 183),
1 Stop Box Lid Lifter,
1 pair 6-inch Combination Pliers (D, Figure 62),
1 Force Pump (A, Figure 70, page 203),
1 6-ft. Rule,
1 12-inch Compass Saw,
1 Stock, with dies and guides for pipe $\frac{1}{8}$ to 1-inch (A, Figure 27, page 139),
1 Stock, with dies and guides for pipe $\frac{3}{4}$ to 2-inch (A, Figure 27),
1 Electric Hand Torch (C, Figure 55, page 180),
25 feet Galvanized Wire, No. 10 gauge (for wiring service),
1 10-inch Trimo Wrench,
1 14-inch " "
1 18-inch " "
1 24-inch " "
Case for Order Cards.

METER WAGON MATERIAL

BUSHINGS

NUMBER	SIZE
2	$\frac{3}{8}''$ x $\frac{1}{4}''$
8	$\frac{1}{2}''$ x $\frac{3}{8}''$
6	$\frac{3}{4}''$ x $\frac{1}{2}''$
6	$1''$ x $\frac{3}{4}''$
6	$1\frac{1}{4}''$ x $1''$
3	$1\frac{1}{2}''$ x $1\frac{1}{4}''$
1	$1\frac{1}{2}''$ x $1''$
1	$2''$ x $1''$
1	$2''$ x $1\frac{1}{4}''$
1	$2''$ x $1\frac{1}{2}''$
1	$2\frac{1}{2}''$ x $2''$

CAPS

NUMBER	SIZE
10	$\frac{3}{8}''$
2	$\frac{1}{2}''$
3	$\frac{3}{4}''$

COUPLINGS

NUMBER	SIZE
8	$\frac{3}{8}''$
2	$\frac{3}{8}''$ x $\frac{1}{8}''$
2	$\frac{3}{8}''$ x $\frac{1}{4}''$
8	$\frac{3}{4}''$
2	$\frac{3}{4}''$ x $\frac{3}{8}''$
6	$\frac{3}{4}''$ x $\frac{1}{2}''$
6	$1''$
2	$1''$ x $\frac{3}{4}''$
2	$1\frac{1}{4}''$
2	$1\frac{1}{4}''$ x $1''$
4	$1\frac{1}{2}''$ x $1\frac{1}{4}''$
4	$1\frac{1}{2}''$ x $\frac{3}{4}''$

COCKS

NUMBER	SIZE
15	$\frac{3}{4}''$ Meter
3	$1''$ “
2	$1\frac{1}{4}''$ “
2	$1\frac{1}{2}''$ “
6	$\frac{3}{8}''$ Straight Gas
2	$\frac{1}{8}''$ x $\frac{3}{8}''$ Pillar

CROSSES

NUMBER	SIZE
3	$\frac{3}{4}''$
3	$1''$
6	$1''$ x $\frac{3}{4}''$

ELLS

NUMBER	SIZE
2	$\frac{1}{4}''$
12	$\frac{3}{8}''$
4	$\frac{3}{8}''$ Drop
3	$\frac{3}{8}''$ x $\frac{1}{4}''$
6	$\frac{1}{2}''$
25	$\frac{3}{4}''$
10	$\frac{3}{4}''$ x $\frac{1}{2}''$
10	$\frac{3}{4}''$ x $1''$
4	$\frac{3}{4}''$ 45°
20	$1''$
4	$1''$ 45°
3	$1\frac{1}{4}''$

SERVICE ELLS

NUMBER	SIZE
18	$\frac{3}{8}''$
2	$\frac{1}{2}''$
40	$\frac{3}{4}''$
20	$1''$
15	$1''$ x $\frac{3}{4}''$
4	$1\frac{1}{4}''$

HOOKS

NUMBER	SIZE
20	$\frac{1}{2}''$ Iron
20	$1''$ “
12	$1''$ x $4''$ Wire
3	$1''$ x $6''$ “
3	$1''$ x $8''$ “
3	$1''$ x $10''$ “
15	$1\frac{1}{4}''$

NIPPLES

NUMBER	SIZE
6 each	$\frac{1}{4}''$ close to $3''$
11	$\frac{3}{8}''$ “
10	$\frac{3}{8}''$, $2''$ to $6''$
3	$\frac{3}{8}''$, $7''$ to $12''$

NIPPLES

Number	Size
6 each	$\frac{1}{2}''$ close
1 “	$\frac{1}{2}''$, $2''$ to $8''$
30	$\frac{3}{4}''$, “
6 each	$\frac{3}{4}''$, $2''$ to $18''$
20	$1''$ close
6 each	$1''$, $2''$ to $6''$
4 “	$1''$, $7''$ to $16''$
8	$1'' \times 20''$
4	$1'' \times 24''$
4	$1'' \times 30''$
6	$1'' \times 36''$
4	$1\frac{1}{4}''$ close
2 each	$1\frac{1}{4}''$, $2''$ to $10''$
1 “	$1\frac{1}{4}''$, $11''$ to $16''$

PLUGS

12	$\frac{3}{8}''$
3	$\frac{1}{2}''$
15	$\frac{3}{4}''$
15	$1''$
3	$1\frac{1}{4}''$
2	$1\frac{1}{2}''$

LONG SCREWS

2	$\frac{3}{8}''$
2	$\frac{1}{2}''$
4	$\frac{3}{4}''$
2	$1''$
1	$1\frac{1}{4}''$
1	$1\frac{1}{2}''$

METER SHELVES

8	5-lt.
4	20 “
4	60 “
10	Wall Boards

STRAPS

Number	Size
4	$\frac{3}{8}''$
4	$\frac{1}{2}''$
4	$\frac{3}{4}''$
4	$1''$
4	$1\frac{1}{4}''$

PLAIN TEES

4	$\frac{3}{8}''$
3	$\frac{3}{8}''$ Wall
4	$\frac{1}{2}''$
10	$\frac{3}{4}''$
4	$\frac{3}{4}'' \times \frac{3}{8}''$
4	$\frac{3}{4}'' \times \frac{3}{8}'' \times \frac{3}{4}''$
4	$\frac{3}{4}'' \times \frac{1}{2}'' \times \frac{3}{4}''$
6	$1''$
4	$1'' \times \frac{3}{4}''$
2	$1\frac{1}{4}''$
2	$1\frac{1}{4}'' \times \frac{3}{4}''$
2	$1\frac{1}{4}'' \times \frac{3}{4}'' \times 1''$
2	$1\frac{1}{4}'' \times \frac{3}{4}'' \times 1\frac{1}{4}''$

METER UNIONS

6	3-lt.
16	5 “
16	10 “
4	20 “
4	30 “
2	45 “
2	60 “

UNIONS

2	$\frac{1}{4}''$	With Washers
6	$\frac{3}{8}''$	
2	$\frac{1}{2}''$	
10	$\frac{3}{4}''$	

For emergency work, especially if close to the shop, a single meter may be carried by a strap thrown over the fitter's shoulder and secured to the meter screws by snap hooks and special screw caps. At times, also, if a bicycle is not available, the meter can

be carried over the shoulder of the fitter going afoot. In every case where there is no wagon, and connection work is required, the necessary material is put together in the shop from a sketch previously made on the consumer's premises.

In one situation both time and expense have been saved in making new sets, by the practice of having a sketch for the meter connection made by the house pipe inspector at the time he makes the pressure test on the fixtures. Each sketch is filed by street and number, and when a set order is received, the proper sketch is taken out of file, the necessary connection made up and sent out on the meter wagon. This decreases greatly the rest time of the meter wagon.

The second class of meter work comprises turning on and off (called locking and unlocking, where the practice is to lock meters not in use), and prepayment meter complaint work. This work should be done from a bicycle, or perhaps a motorcycle (Figure 72, page 206) where the distance between jobs is long, as on the city's edges or in the suburbs. The tools required are carried in the tool bag (Figure 65, page 196) and are listed on page 197. For prepayment complaint work, additional tools as follows are needed:

1 No. 5 Harwood Screw Driver,
1 Small Flat File,
1 " Half-round File,
1 " Rat-tail File,
1 pair 4-inch Flat Nose Pliers.

In general, a man who is sufficiently trustworthy to be a meter fitter should not need an inspection of his work. However, it has been found in Philadelphia that there is a constant tendency to sacrifice the finer points of the work in order to gain speed, and in this way increase the causes of meter leaks, because of strain from improper shelf support, or badly run connections. To counteract this, a certain percentage of all meter work is viewed by an inspector reporting directly to the Superintendent of Meters, and this has resulted in a high standard of performance. In addition, the district foreman, and sometimes an inspector, sees a certain amount of all meter work in the course of his daily round.

Detailed Instructions to Men

The attempt to place a fitter in a position where he will generally know what to do under every condition that may

arise in meter work, involves the preparation of many rules. At the same time, the larger the organization, the more necessary are written rules to insure good service. The preparation of such rules and the means taken to keep them up to date are described in Chapter IV. The more nearly these rules approach perfection in meeting local conditions, the less are they adapted for exact quotation in a general treatise such as this is. Therefore, the instructions which follow are not to be considered as complete. As a case in point, no mention is made of prepayment meter complaint work. The directions for this are peculiarly dependent upon the particular type, or types, of prepayment mechanism in use.

First will be given those rules of behavior and the general methods and precautions that should be followed by all employees.

General Rules

Behavior

The policy of the company is to give prompt service and complete satisfaction so far as its rules will permit. You should be courteous at all times to your fellow employees, consumers and the public in general, but not talkative. Never discuss the company's affairs, nor give advice except to consumers concerning the work on which you are engaged. Politely refer all inquiries regarding gas matters to the shop.

When dealing with consumers inclined to be unreasonable, ill-tempered, or even abusive, show every possible courtesy and carefully avoid loss of temper. By conducting yourself this way, you not only work for the interests of the company, but for your own best interests.

To gain access to a house, ring bell or knock. If there is a side yard, so that you may enter by kitchen door, apply there first; but if the house is in a solid row, apply at front door. Before entering, wipe your shoes and remove your hat. Ask consumer where you should enter and leave the house during the progress of your work, and, if possible, accept the entrance the consumer selects. If request is unreasonable, ask permission to enter another way, but do not object to using the back door; do not use the front door without consumer's consent.

Do not enter premises without consumer's knowledge, and never enter a house or any room against his wishes.

As far as possible, do not enter the various rooms in a house alone. Have consumer, or a servant, accompany you. Always knock (even though the door may be open) and gain consent of any one in a room before entering. If it can be avoided, do not enter a room where guests are being entertained, or where a meal is in progress.

A reasonable degree of cleanliness as to your person and clothing is expected, according to the work on which you are engaged.

Wearing your hat in any part of consumer's premises, except cellar, expectorating anywhere in or around the premises, eating on front steps, and hanging clothes on front fence, are prohibited.

Profanity, loud talking, unseemly conduct, and drinking intoxicating liquors of any kind, are prohibited.

Promptness in reporting for work in the morning, and resuming work after luncheon, is expected.

If possible, give notice before starting time if unable to come to work. Report at once if you stop work after starting. If absent from work, report your intended return at least one day prior to returning.

Notify your foreman promptly when you change your address.

Always wear your badge and uniform during working hours. Show consumer badge on request.

Never leave your work to go to a fire unless instructed to do so, in which case you must have a fire-line badge, or be accompanied by a foreman who has one.

Never, during working hours, canvass or sell articles for your own account, and at no time state that the company approves an article in which you are interested.

Make no complaints, favorable or otherwise, about anything in consumer's house.

General Methods and Precautions

You are never warranted, even to save time or money, in adopting a method of doing any work which involves danger, if there is a safer method.

The dispatching clerk, who is an assistant to the General Foreman of Fitters, is always available to consult with about your work, either by telephone or when you are in the office. When you are uncertain what to do, or when a consumer makes a special request that you cannot grant, use the nearest available telephone. If, however, the General Foreman of Fitters, or one of his outside assistants, visits the job after the shop has instructed you what to do, relate the circumstance to him, including the instructions received, and then be guided by his instructions.

As far as possible, confine your work in consumer's premises to the class of work done by your department.

Never begin work in a consumer's premises without first explaining the nature of the work and obtaining permission to go ahead. When the work involves the temporary turning off and on of the gas supply, this fact should be fully explained when asking for permission. In a business place, obtain the permission from the person in charge. In a dwelling, it is preferable to obtain permission from a member of the family, and, if you have any choice, to consult the one whom you think has the most authority, but, of course, you must avoid giving offense.

If a servant answers the door, explain the work and ask her to get permission from a member of the family. If no member of the family is in, and the servant of her own accord gives you permission, do the work, unless it is of such a character, or conditions are such that you do not feel warranted in taking the responsibility

of going ahead on the servant's permission. In such a case, telephone the shop before making any decision.

In any case, if permission to do the work is not granted, do not proceed with it.

To suit the convenience of a consumer, you may wait for fifteen minutes. If a longer wait is requested, explain it is against the company's rules. Make no promise as to when the work can be done, except to say that you will ask the shop to send a man promptly. If a later hour of the same day is requested, make no promise, but tell consumer that you will telephone the request to the shop at once. If a later date is requested, state it on your order.

If you are not competent nor able to do work specified on order, tell consumer another man will call. If consumer is inconvenienced, telephone shop.

While working at consumer's premises on any kind of order, if you cause a leak or an obstruction, or damage piping or fixtures, make a permanent repair if possible, regardless of its extent. If unable to make repair, report case to shop.

If, from the nature of a complaint, or for any other reason, you think consumer needs guidance in meter reading, inserting coin, etc., give the necessary instructions.

If any work involves much more expense than the order seems to warrant, or than similar work usually costs, consult shop before going ahead.

Do not lay materials or tools on cellar stairs, or anywhere where persons are liable to stumble over them.

When working on an order of any kind, if you notice that the prepayment mechanism of meter has been tampered with, or the cash box broken, notify consumer and have him present when you remove money. Report facts on order.

After you have completed your work at consumer's premises if you know that another workman will call to do additional work, state this fact to consumer.

Never open a service cock before making sure that the meter cock is shut, or pipe closed.

Unless otherwise specifically instructed, never do the following work with the service cock open:

Removing plug or cap from end of service.

Disconnecting any portion of meter connections between service and meter cock.

Setting or removing pressure gauge at head of service unless the pressure is taken from a $\frac{1}{8}$-inch hole tapped in service.

Never leave the stop key on service cock while working in the premises.

If you find gas off at service cock, or at plugged swivel, when, from the nature of the order, you expected to find it on, telephone the shop.

Before removing any plug or loosening a joint, where the gas supply is controlled by a valve at the meter instead of a cock, make sure that gas is off by trying a burner on the system supposed to be cut off.

If your work requires the unscrewing of a cap, plug, fixture key, appliance cock key, or piece of pipe not larger than $\frac{3}{8}$-inch, gas need not be shut off if consumer objects, but before starting the work with gas on, observe the following:

Have a plug (cork or rubber) of the proper size to fit into the opening through which the gas might flow.

Examine the threads of the pipe or fitting to be inserted.

See that no gas is lighted nearby.

Make sure that even a slight escape of gas will not injure any person, especially an invalid, or a domestic pet.

After completing work with gas on, examine carefully for unlighted pilots.

In all other cases, working against gas is prohibited, except when you are specifically instructed to do so by the dispatching clerk or a foreman, in which case at least two employees must be present.

A lowering of the pressure in a system of piping, even if momentary, may result in the extinguishing of a burner; it is, therefore, dangerous to restore the pressure without observing all the precautions given for turning on gas.

If gas was on when you started work, arrange your work so that if unable to complete it before quitting time, you can turn on gas for the night. If anything prevents your turning on the gas, telephone the shop before leaving.

If you shut gas off in error, and for any reason cannot turn it on, telephone shop. Report all cases where you find gas shut off in error.

If consumer is deprived of gas for any reason, and you cannot remedy the trouble, if gas is wanted the same day, telephone shop.

Remove carefully from the premises any surplus material, dirt, or any odor arising from illuminating gas, that may have accumulated as a result of your work, or that done by another employee. Condensation, or any contents of service or meter, should be removed as quickly as possible and disposed of. The odor from this is as objectionable as that from live gas. Where such contents may fall upon coal, spread canvas on the coal so as to catch whatever may come from the service.

Be careful not to damage electrical meters, wires or any property belonging to other companies. Telephone shop at once if you do any damage.

If your work requires the disconnection of wires, disconnect them, unless work which you are not competent to perform is necessary to restore the wires to their original condition. In such cases, tell consumer that wires must be removed before work can be done, and that the shop will arrange for their removal. Note on order to whom wires belong.

Replace and secure any pipes or wires that you may have moved or bent out of place in the course of your work.

Never let your haste to finish a job at quitting time lead you to omit any of the precautions against turning the gas into open, or leaking, pipes. Always make the test prescribed. Carelessness caused by haste has caused many bad accidents.

Do not forget the danger of explosion. Extinguish any nearby existing flame or fire, and do not use an unprotected flame or strike a match when:

Testing piping or joints.

Hunting for leak, whether or not you smell gas.

Hunting for open cock, or leak as shown by test hand after turning on gas.

There is an odor of gas, no matter what work you are on.

Working on fixtures, appliances or piping when gas may escape, unless you have shut the cock controlling the flow of gas.

Entering room or cellar where combustible or explosive material is known to be stored.

Condensation has been spilled or exposed to the air.

Working in a confined space, such as under floors, if there is a possibility that gas may be present.

If a light is required for the above work, use an electric torch.

When permitted to use an unprotected flame in the cellar, carry it below the waist, and if gas is on, keep it within three feet of the floor. Endeavor to keep it on a lower level than the meter, and never bring it closer than is necessary to enable you to see the dial or part you wish to inspect. Never allow flame to come in contact with the meter, meter connections, or any piping.

Use only the safety matches furnished by the company. Place burnt match sticks in a receptacle used for that purpose, or bring them away with you. Never throw them on the floor.

Never carry gasoline or benzine into a building except the small quantity in the plumber's furnace.

When using candle, do not allow the grease to drop where it can do damage. Remove any grease that drops, or that served to hold candle.

When your work necessitates damaging plaster, flooring, surbase, or special construction of any kind, or if anything on the premises which you are required to disturb, is in such a condition that your work may injure or destroy it, before starting work, have consumer or his representative sign a release, after explaining its meaning. In the latter case, the consumer's name per his representative should be given.

The release, however, does not permit you to do unnecessary damage or to soil the walls. Make no hole larger than necessary. Take up flooring, surbases, etc., neatly so that when replaced, an unsightly joint is not left.

As the company desires consumers to have good gas service, report to the shop any faults you notice in appliances, service, meter, meter connections, or meter location, that are beyond your province or ability to remedy. Do not mention the matter to consumer. This has no reference to work to be done by another employee, but to defects noticed without being called to your attention by consumer. If able to remedy trouble, do the work even if not called for on your order.

If you notice open-flame burners not protected by glassware, near windows hung with curtains, report fact on order.

Do not work with worn-out or defective tools. Ask for new ones. Unless you are working with fellow employees, or in an emergency, do not lend tools to, nor borrow from, employees without permission from a foreman. You may borrow a step-ladder or a bucket from a consumer.

Do not lend tools to the public, but if consumer wishes to borrow one, unless it seriously interferes with your work, you may accommodate him, but never lend any tools overnight.

If while working on an order of any kind, the conditions indicate that meter is too small to give good service, report this fact on order, stating number of burners and names and kinds of appliances in use, and if electricity is used for illumination, to what extent.

Unless specifically instructed to do so, never enter premises where there is a contagious disease. Report the facts on order, or in case of a leak, telephone the shop. When instructed to enter premises, immediately after coming out, wash your hands and face, blow your nose, and gargle your throat with listerine.

Do not accept gifts from consumers, such as tools, material, private meters, gas appliances, etc., without permission from the shop.

When making joints, always use jointing material on the male thread only. Use sparingly to avoid clogging the pipe. To avoid danger of poisoning, never allow your bare hands to come in contact with the jointing material.

If twice within a short period, you do work on a similar complaint referring to the same meter, appliance or piping, or learn that another workman has done similar work, report the fact on order, even though you believe you have remedied the trouble. This is especially important when the complaint is about insufficient supply.

Do not disconnect and leave an appliance in vacant and open premises.

When working on an order of any kind, if you discover a leak coming through cellar wall after turning on service cock, shut it off, thoroughly ventilate premises, and telephone the shop.

Work Order Specifications

Before starting on your route, examine your orders to see if you have been given any special or specific instructions, and arrange your calls in the best manner. If an order is stamped "Immediate attention," attend to it before doing other work. In case you receive several such orders at the same time, take them in turn, but attend to all before doing any other work. If an order is stamped to show at what time the call is to be made, arrange your route accordingly.

In writing reports, use a fairly hard, well-sharpened pencil (not indelible). To avoid errors, use care, avoid flourishes, and do not write hurriedly. Make figures legible; the numerals 3, 5 and 8 resemble one another and should, therefore, be made distinctly to avoid error in reading.

Before leaving premises, enter all the data asked for on order, or give reason for omission. Note on order everything that

you should report to the shop. Never trust to your memory. Enter only the completed report on the face of the order. Put general explanations, remarks made by consumers showing dissatisfaction, etc., and notes on back.

When you complete a charge order, simply fill in your name and date, unless you have not completed order exactly as specified, in which case, report what you did and why change was made.

On all orders, report exactly what you did, whether or not it agrees with the work called for. If conditions found do not agree with this data, state this fact on order.

If you do not entirely complete order, enter report on back, under which state the time you arrived and left the job. The printed space for filling in time arrived and time left is to be used only by the workman who completes the order.

When unable to complete a job the same day as started, fill in the date started and date finished, in addition to reporting the time.

In making report, never write more than is necessary, but always write enough to explain what you have done. Note below the incorrect and correct way of making report:

UNNECESSARY WORDS	A BETTER WAY
Examined and found leak in key of fixture in second floor front room. Greased in O.K.	Greased in leaking fixture key 2nd floor front room O.K.

When reporting repairs to prepayment meters, if any damage was done by you, so state, so that consumer will not be charged.

If you enter the room where the meter is, enter on order the company's number and index of the meter to which order refers. Do not write this data on another paper and then copy it on order. Data for other meters on premises need not be entered.

When a drawing of the index dial is required, carefully examine the position of the one-thousand hand, and place pencil point on the corresponding position on the edge of the one-thousand hand circle on order, and draw a line toward the center of the circle. Follow this method for the other dial hands. Never write the index and attempt to draw the dial from your figures. As a wrong drawing may lead to an incorrect bill being rendered to the consumer, you can readily see the importance of a correct drawing.

In every case where immediate attention should be given an order, and you have not been instructed to telephone the shop, you should upon your arrival there, in addition to giving details on order, refer the case to the dispatching clerk.

If the wrong name or address is given on order, locate the correct one if possible and do the work. Report the correct name or address on order. If order is for corner property and no house number is given, if possible, report the number. Rectify any other errors, such as wrong meter number, etc., that you notice, but make no erasures.

Meter Work

Meter Reading

The general rule for reading the index of a gas meter is: Begin with the left-hand dial, and put down the figure that each hand or

pointer *has passed* (every alternate dial being read in the reverse direction) until the last, or "1 thousand" dial, is reached; for this last dial the rule is:

If the hand has not yet gone halfway to the next number, the number that has been passed should be taken, or if it is past the middle point, then the larger number should be taken, and if there is any doubt, the larger number should be taken.

For example, the index here shown should read 793:

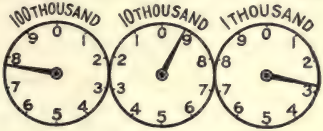


Figure 144.

However, owing to defects, or inaccuracies, in the construction of dials and indexes, the above rule, that for all dials (except the "1 thousand" dial), the figure that *is passed* shall be taken, cannot be blindly followed. Some of the hands may be more or less out of place, so that they read "fast" or "slow," and the meter reader must learn to examine every index he takes with a critical, suspicious eye, in order to make sure that he has not been misled by the inaccuracies referred to.

The meter index is so constructed that the hand on each dial moves through one space on that dial in the same time that the hand on the next dial to the right makes one complete revolution. In consequence, the positions of the different hands on the index bear a definite relation to each other; so that, by looking at the right hand, or "1 thousand" dial, one should be able to tell in what part of one of the spaces, the hand on the "10 thousand" dial will be found. In the same way, the position that should be occupied in one of the spaces on the "100 thousand" dial, could be foretold by examining the position of the hand on the "10 thousand" dial; and so on, from dial to dial.

For example: If the hand on the "1 thousand" dial reads 5, indicating that it has made half its total revolution, then we know that the other hand on the "10 thousand" dial should be midway within whatever space it occupies; if the hand on the "1 thousand" dial reads 2, indicating that it has made one-fifth of its total revolutions, then the hand on the "10 thousand" dial should be found, in whatever space it occupies, to be at a point which is one-fifth of the space from the beginning of the space; if the hand on the "1 thousand" dial reads 8, then the hand on the "10 thousand" dial should be at a point, in the space it occupies, that is four-fifths of the space from the beginning of the space; and so on.

The meter reader should accustom himself to habitually observe this point of the relative positions of the hands on the adjoining dials, so that if any hand is misplaced, even slightly,

he will notice it; for on the certainty of his noticing any displacement of any hand will depend, to a great extent, his ability to read meter indexes correctly.

Now it will be asked, suppose the meter reader notices a misplaced hand, how is he to read it? He must use his judgment, and of two possible readings, must take the one that assumes the lesser displacement of the hand.

Consider the index here printed:

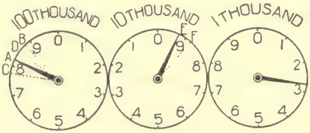


Figure 145.

If the rule were followed blindly, the reading would be 893. A competent meter reader would, however, see immediately that something was wrong; because the hand on the "10 thousand" dial has almost completed a revolution, and, therefore, the hand on the "100 thousand" dial should have almost completed a space, and yet there is the hand on the "100 thousand" dial which has completed only a very small part of its space.

It follows that this hand is misplaced, and the question is, on which side is it misplaced? If the hand is misplaced *forwards*, then its proper position, in order to correspond with the hand on the "10 thousand" dial, would be as shown by dotted line C, and the reading would be 793; if the hand is misplaced *backwards*, then, in order to correspond with its right-hand neighbor, it should be as shown at dotted line at B, and the reading would be 893.

Now which of these two positions is the correct one, or the one which the hand should occupy? It is more reasonable to take the position at C, than the one at B, because by accepting C, you accept the position that requires you to assume the lesser amount of displacement of the hand. C is much closer to A (the actual position of the hand) than B is, and, therefore, position C should be taken, and the correct reading is 793.

Suppose now, that the hand on this dial, instead of being located at point A, should have been so far misplaced as to show at point D. Then how should the meter be read? Here the meter reader, in mentally estimating the distances between the actual position of the hand (D) and the two possibly correct positions (C and B), in order to determine which, being the lesser, should be accepted, is puzzled to find that the distances are the same, or practically the same, and is consequently at a loss which reading to accept.

In this case, where a hand is misplaced to the extent of one-half, or nearly one-half, of a space on a dial, there is no way in which the meter reader can determine which is the correct

reading, he should put down both readings, with a question mark, and he should show the positions of the hands on a sketch of the dial, and report the defective dial to the dispatching clerk.

Fortunately, *very few* dials are so inaccurate as the one in the last example; usually, the displacement of the hand is small, and the meter reader can easily compare the two distances and accept the smaller one. In all such cases, note should be made on the back of the card that the dial is defective. The inaccuracies on the dials are usually of such a nature that the hand will register correctly in some parts of its circle, while it will be out of place at other points.

The explanations made above apply also to the reading of the "10 thousand" dial. For instance, if the hand on this dial had stood at point F instead of point E, the correct reading of this dial would still be 9, because as the hand on the "1 thousand" dial (the next one to the right) has travelled over only a small fraction of its circle, we know that the hand on the "10 thousand" dial should be a small fraction of a space beyond either the 8 or 9, and we accept the 9 as being correct, because it is a less violent assumption than it would be to accept the 8.

The principle involved here is the same as the one involved in telling the time from a clock face with the hour hand slightly misplaced. The minute and hour hands bear somewhat the same relation to each other as do any two adjoining dial hands on a meter index; the one makes a whole revolution, while the other goes over one space. In the clock face, both hands are on one dial, while in the index the dials are separate.

Now, a clock face as here shown,

Figure 146.

would be read as ten minutes to one, instead of ten minutes to two, because it is evident, at a glance, that the hour hand is misplaced, and it is more reasonable to suppose that of the two misplacements that are possible, the smaller one is the real one.

Especial care must be observed when the left-hand dial on the index has just about completed, or has just passed, its revolution, so that the hand stands near the 0 point.

For instance, in Figure 147, the reading is 993:

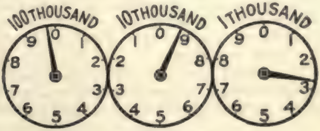


Figure 147.

Also, in Figure 148, the reading is 993.

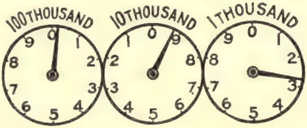


Figure 148.

In Figure 149, the reading is 003, or 3.

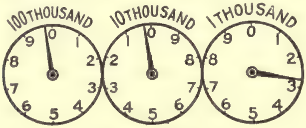


Figure 149.

In this last case, while 3 is the reading that ought to be entered on the card, it should be understood, that, when this reading is used in the office, to determine the quantity of gas that has passed since the last preceding reading, it may be necessary for the bill clerk to assume this reading as 1003; for, if the last reading had been 962, the difference between the two, or 4100 cu. ft., is the quantity of gas passed. When, however, the bill clerk records this reading where it will be used to determine the quantity of gas passed between it and the next *following* reading, he will ignore the 100,000 cu. ft., which represents a complete revolution of the left-hand dial, and make a fresh start by calling the reading simply 3.

The usual practice in indexing meters is to omit the two ciphers which represent tens and units, thus reading no closer than the nearest hundred.

For instance, in Figure 144, this reading 793 indicates that 79,300 cu. ft. had passed since the meter started at 0. In Figure 148, 99,300 cu. ft. had passed since the meter had started at 0.

Do not be confused by the fact that the alternate dials read in reverse directions; accustom yourself to follow on each dial the direction in which the figures run.

With these explanations in mind, we are now in shape to write the following rules for reading meter indexes:

1. Begin with the left-hand dial, and mentally select the figure which the hand *has passed.*

2. Immediately verify the figure so selected, by looking at the next dial to the right.

3. If the position on the hand of the second dial is such that it corresponds with that on the dial you are reading (the first dial), then accept the figure you have selected, and put it down.

4. If, on the contrary, these two dials are not theoretically, in their correct relative positions, then, assuming that the hand on the dial you are reading (the first dial) is misplaced, mentally place the hand on this dial at the point where you believe it ought to be.

After you have selected the proper point for the hand on the dial, then adopt the figure that belongs to that point; i. e., assume the hand to be in its proper position, and then take the figure that the hand in this assumed position *has passed* and put it down. This may, or may not, be a different figure from the one you had first selected.

5. Having thus determined the correct figure for the first dial, begin with the second dial, and go through the same process with it, using the dial on its right (the third dial) to check or verify the figure first selected on the second dial.

6. Repeat this process for each dial, each one being verified by its right-hand neighbor, until you come to the last dial (the "1 thousand" dial).

7. In reading the "1 thousand" dial, as it has no right-hand neighbor, a different rule obtains. If the hand has not yet gone halfway to the next number, the number it has passed should be taken; or if it has passed the middle point, then the larger number should be taken, and if there is any doubt, the larger number should be taken.

8. Omit the two ciphers that represent tens and units; thus your reading as written contains only the figures you read from the dials.

9. In any particular case, if the hand is so far misplaced, or if for any other reason, you are *in any doubt* as to the correctness of the reading you have taken, always express your doubt on the order by a question mark (?) after the reading, and mark the positions of the hands on a sketch of the dial on the order.

10. Make clear, legible figures. Keep your pencil fairly sharp.

11. Incorrect meter readings involve the company in serious trouble; therefore, the meter reader should exercise the *greatest care*. There is no excuse for carelessness in putting down figures, when errors in them cause so much harm.

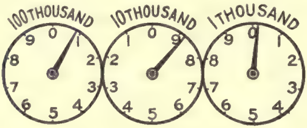
12. Make a note on the order, calling attention to any dial, the hand on which is, in your opinion, far enough misplaced to make errors liable.

13. In reading meters, always follow with the eye the line of pipe connecting the service with the meter, to make sure that no connection has been made from it for the purpose of using unmeasured gas. This does not mean that the average gas consumer is suspected of dishonesty, but if the meter readers, and any of the company's employees who may read the meter for any purpose, habitually, as a matter of course, glance along the pipe, this practice constitutes an excellent means of detecting such connections.

14. In removing a meter, read the index before the meter is removed from its shelf; when setting a meter, read the index after the meter is in permanent position on its shelf.

15. When you are in the house of a consumer, and the work requires you to obtain access to the meter, *read the index*, and record the reading on whatever order you may be working on.

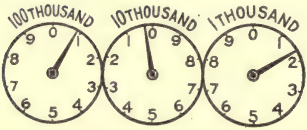
16. Sample indexes, with the "careless reading" and the "correct reading" in each case, are given below:



Careless Reading 80

Correct Reading 90

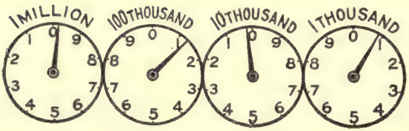
Figure 150.



Careless Reading 2

Correct Reading 102

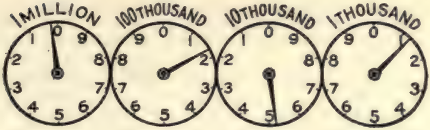
Figure 151.



Careless Reading 9101

Correct Reading 101

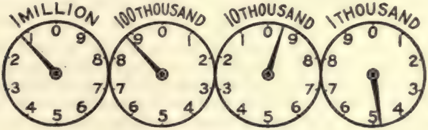
Figure 152.



Careless Reading 151
Correct Reading 151

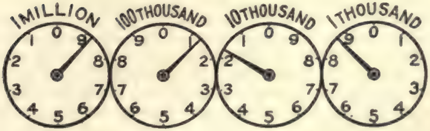
Figure 153.

In this case, the "100 thousand" hand is misplaced, but its correction does not affect the reading.



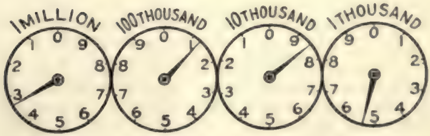
Careless Reading 1895
Correct Reading 895

Figure 154.



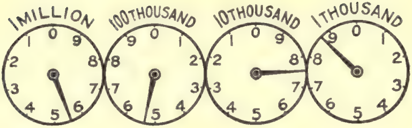
Careless Reading 8119
Correct Reading 9119

Figure 155.



Careless Reading 3185
Correct Reading 3085

Figure 156.



Careless Reading 5579

Correct Reading 5579) ? with sketch and
5479) note.

Figure 157.

In this case the "100 thousand" hand is so far misplaced that the correct reading cannot be told with certainty.

General Requirements

Always keep meters upright, but if tilting is unavoidable, incline them so that the inlet side is kept lower than the outlet side. When possible, meters in wagons should be placed on the side shelves and securely strapped, but whether placed on the shelves or on the floor, the meters should be carefully supported to prevent shifting and damage; and pads should be placed between, beneath and back of them. Use the same care in handling old meters as new ones.

Never throw a meter; never leave it on the sidewalk, and never chalk the index reading on a meter.

Do not lean against a meter or meter connections.

Before doing any work at a meter, or meter connections, verify the company's number of meter and the consumer's name.

To provide an opening for cleaning out riser and house pipes, a tee (or cross) should be placed on the lower end of house riser. Therefore, when you disconnect a meter for any purpose, if this fitting is missing, supply it if you have the necessary tools and material with you.

When removing condensation, do not "dump" or pour it out of a meter. Use a pump to remove the liquid from the meter column into any glass or metal receptacle known to be tight. Be very careful not to spill any of the condensation, but if any spills, either in the house or on the street, apply vinegar or chloride of lime to deodorize.

When possible, do this work in the cellar or basement, and remove the condensation from the premises as quickly as possible, but if there are any inflammable goods nearby, or if consumer claims, or you fear, that the odor will damage the goods, or if any flame or fire is unavoidably close, carry the meter outdoors to remove the condensation, a back yard or vacant lot being preferable to the street.

In all cases, pour the condensation into a newspaper and burn it in a safe place (preferably a back yard or vacant lot) and stay on the spot until it is all consumed and the fire is out.

Never burn condensation in a busy street.

An excessive quantity of liquid in the bottom of a meter, as determined by its increased weight, does not necessitate the immediate removal of this liquid from the meter. Change the meter, or order it changed.

If you find that a meter has been "dumped," change it, or order it changed.

Never use fire to thaw out a meter. Pour hot water over the part thought to be frozen, until the meter will pass gas. If not advisable to use water, wrap hot bagging or hot cloths around the meter.

Report all meters found badly rusted or being affected by steam, acid fumes or dampness, and any undue weight or strain on meter or connections, such as boxes on meters, clothes-lines attached to connections, or governor not supported firmly.

If consumer requests you to loosen meter cock, state that you are not permitted to do so, and explain the danger incurred in turning gas off and on.

Turning On Gas

The turning on of gas is a process that merits your utmost care and closest personal attention. The possibility that gas was burning at the time the shut-off was made and may, therefore, escape when again turned on; the possibility that some person may open a burner while the gas is off and carelessly leave it open; and the possibility that your work, or some other cause, may have started a leak while the gas is off, should impress you with a sense of responsibility when you turn gas on.

When it seems advisable to turn on gas without complying literally with the following rules, do not take the responsibility, but telephone to the shop, unless you have been given specific instructions how to proceed.

When ready to turn on gas after a temporary shut-off, examine any independent appliance line with special reference to the possibility of the end being open, and see that service cock is open and meter cock closed. When turning on gas, whether in the above case, or whether the piping is new, or is old and has been unused for some time, in order that you may be positive that no gas is escaping after you have turned it on, carefully follow Precautions Nos. 1, 2 and 3. As each precaution is intended to serve as a check on the other, carry out each one as thoroughly as though it were the only one.

The workman in charge should personally make the tests described in Precautions Nos. 1 and 3, and should never trust anyone else to make them.

Precaution No. 1:

This consists of a test of the meter to determine whether it is in proper condition and will indicate a very slight flow of gas through it. It is called "Test A."

As the value of Test A depends largely upon the condition of the test cap (Figure 59, page 187), care should be exercised to protect it from damage. When not in use, keep it in the test cap box. *Renew the washers when necessary. Return the cap*

when it is evident that the size of the hole has *increased or decreased.* Never ream or clean out hole with any hard or sharp instrument. Before using a test cap, make sure the orifice is not obstructed.

If the meter is provided with screw connections, open the meter cock and allow the mixed gas and air to blow from the open outlet column for about four seconds. Screw the 2-cubic-foot test cap on the outlet screw, watch the test hand and tighten the cap by hand when the test hand has reached a point on the dial from which you can properly judge its movement. Now watch, and continue to watch, the test hand either until it has moved, or until the maximum time given in the table below has elapsed.

If the meter is provided with flange connections, bolt test cap loosely to the outlet flange, and open valve on inlet connection to allow the mixed gas and air in the meter to escape. When a movement of the test hand is seen and the hand has moved to the proper mark, bolt the test cap tightly and proceed with the test, using the 2-cubic-foot cap when the meter supplies gas to one or more sleeping rooms, and the 6-cubic-foot cap in all other cases.

Capacity of Proving Head in Cu. Ft.	Maximum Time in Minutes to Watch for a Movement of			
	Test Hand		Extra Test Hand	
	2 c. f. rate	6 c. f. rate	2 c. f. rate	6 c. f. rate
2	2	–	1	–
5	3	–	1	–
10	6	–	2	–
20	12	–	2	–
50	30	10	4	1
100	60	20	–	–

When making test, note on order the actual time required. To avoid any odor of gas on the premises, ventilate cellar or room if possible.

If the test hand does not move in the maximum time shown in the preceding table, the meter has failed to pass the test, in which case send for a new one and give it the same test; or if you see any difficulty in getting another meter in time to give consumer gas when desired, telephone the shop at once.

As it is important to give consumer gas immediately upon completion of your work, do not defer Test A until too late in the day, and if it is evident that your work will not be completed until near the close of the day, it is advisable to make the test prior to the time you are ready to turn gas into the piping.

When the meter passes Test A, shut meter cock, remove test cap from outlet screw, connect meter to outlet connection, leave gas off at meter cock, and follow Precaution No. 2.

Precaution No. 2:

This consists of an examination to see that the gas is shut off at all burners and appliances.

Explain to the consumer the importance of this precaution, have him carefully examine to see that every burner and appliance in the premises is closed, and where an instantaneous automatic or automatic storage water heater is installed, make sure that the main gas valve and pilot valve are closed. Inquire particularly if anyone is asleep in the premises, and use especial care in boarding and apartment houses. If rooms are locked and consumer thinks they are empty, advise him to enter the room if possible. Do not take consumer's assurance that all burners, etc., are shut off until a thorough examination has been made. By explaining the danger, and stating that one is sometimes mistaken in his general impression that all burners are closed, you can usually prevail upon the consumer to make this examination. If consumer is willing, you may accompany him in his examination, but this is not necessary. If consumer refuses to make examination, or you think he has not been thorough, make the examination yourself. If not permitted to do this, leave the gas off and telephone the shop.

After the examination is made and the conditions found to be satisfactory, follow Precaution No. 3.

Precaution No. 3:

This consists of a test of the house piping system made with the meter, and is called "Test B."

Open meter cock and watch meter dial for a movement of the test hand. If it does not show any motion, watch it the same number of minutes as was consumed in Test A, and if it does not show any movement in that time, the system of piping is tight and you may leave the gas on.

If the test hand moves rapidly, shut meter cock and hunt for an open burner or other opening. If you cannot find an opening, repeat the test to make sure of the rapid movement of the test hand. If the test hand still moves rapidly, shut off the gas immediately and continue to hunt for the opening, and until you have found it, do not turn the gas on even temporarily.

If the test hand shows any movement in the period named, and you can find no open cock, pilot or other opening, there is evidently a leak, or leaks, in the piping, fixtures or appliances. Your course of action should then depend upon circumstances as follows:

If the building is a dwelling, or contains one or more sleeping apartments, shut off gas if any motion of the meter test hand is visible in the period named, unless you are entirely satisfied that a very slow motion of the test hand is caused entirely by open pilots which it is inconvenient or impossible to shut off. The fact that you may believe that the same quantity of leakage existed before your visit and that, therefore, you feel certain there is no more danger after turning on than there was before, is immaterial; the leak, or leaks, should be found and stopped before turning on.

Whether this work will be done by the company, or by the consumer, will depend upon the conditions of the particular case, as explained elsewhere. A motion of the hand due entirely to open pilots, should not cause you to leave gas off.

If the building is a factory, shop or other building where all the piping is exposed and does not contain sleeping rooms, be guided by the rate of leakage after examining the system as far as possible, and satisfying yourself that the leakage is not apt to be a source of danger. *All parts of the building should be personally visited by you.* If there is no danger, turn on the gas.

If the building is a store, factory, public assembly room, shop, office or other building equipped with concealed piping and does not contain sleeping rooms, be guided by the rate of leakage and other conditions. Large systems of piping and fixtures that have been installed for some years may contain small leaks which it would be expensive to find and repair and which are not a source of danger. In view of this, in the case of a building of the character named, examine the fixtures and piping as far as possible. If after this investigation, which should include a *personal visit by you to all parts of the building,* you are satisfied that there is no danger and the leakage is small, turn the gas on. Make full report on order.

To avoid any chance of misunderstanding it is repeated that the preceding paragraph does not apply to dwellings, or to any building where people sleep. If any business or public building contains one or more sleeping apartments, it should, in making turn-ons, be treated as a dwelling.

In making a turn-on, when meter shows any gas passing, you should realize your full responsibility and take no chances. If you are not thoroughly satisfied that there is no danger leave gas off and telephone the shop.

If you have shut off gas temporarily from only a section of a piping system, by means of a cock provided for that purpose, the precautions cannot be followed exactly. In such cases, before turning on gas make a personal examination of all burners and appliances connected to the system which has been shut off. If you cannot get into every room, do not turn gas on. Explain facts to consumer and arrange to call again when access to all rooms may be obtained. Report facts on order, or if urgent, telephone the shop.

Never gas up a system of piping through an outlet. When the necessary conditions have been fulfilled, gas up as follows:

If the gas was found off when you began the work, so that the piping is filled principally with air, open at least one burner on each fixture, or appliance, supplied by the meter, and light the gas as soon as it comes.

If consumer objects to your going to an upper floor gas up from a lower floor and advise consumer that the gas may blow and burn blue when first lighted.

If you turned the gas off when you began work, and the piping is consequently filled principally with gas, and your work has been of such a nature that any air may have entered the pipes, open

and light as many of the burners or appliances as may be necessary to convince you that all air has been expelled. Be thorough in this work, as any air left in a pipe leading to any of the burners might lead to an escape of gas and consequent damage. When a meter has been changed, or other work done to the piping in the cellar, which may admit air into the riser, it is not sufficient to blow out the nearest burner in the cellar, or even all the cellar burners; try several of the burners on the first floor, and if air is found to come from them, continue the process until all the burners show gas instantly. In trying first floor burners, let them burn long enough to be sure that when the gas in the piping close to the burners is exhausted, the gas is not followed by a pocket of air, which would extinguish the light. Be careful to blow all the air out of any fuel appliance line, holding a match to a burner until you are sure all the air has been expelled from the line and the gas ignites and burns properly.

If any gas escapes during the process, remove it at once by ventilation.

If you found the service cock shut when turning on gas to a meter, test, by soap suds or sense of smell, the meter and all joints and piping between the head of service and inlet connection, including all header work, provided for other meters. If there is more than one meter supplied by the service, make sure that a plugged tailpiece is placed in all the meters except the one you are turning on. Report on order any work you do on other meters.

Shutting Off Gas

Except as otherwise instructed, never shut off gas without first notifying the consumer.

If your work requires you to temporarily shut off gas, after obtaining consent, ask consumer if any gas is in use, and if so, request that it be shut off. Do not request consumer to make a general examination for open burners at this time, as this would only tend to make him careless or indifferent when requested to make examination when you turn on gas, but caution him not to turn on the gas while you are at work. Before shutting off the gas, watch meter test hand. If it moves, do not shut off until, with consumer's assistance, you have found where the gas is issuing. If an open burner, close it; if a leak in piping or fixtures, or if due to pilot lights that cannot be conveniently shut off, you may shut off the gas.

Do not let this preliminary watching of the test hand influence you to any laxity in following the turn-on precautions, for while it may be of use in certain cases, it is but a very uncertain indication of a leak, as the meter has not been given Test A, and also the conditions may change before you turn on gas.

If for any reason you are required to leave the gas off permanently, notify the consumer.

When the service supplies one meter only, light a burner, shut off gas at curb, then at meter. Examine burner to determine that gas has been completely shut off.

When the service supplies more than one meter, and you find gas off at every meter except the one specified on order, shut off gas at meter and curb.

When the service supplies more than one meter, and you do not find every meter, except the one specified on order, shut off, proceed as follows:

If an ordinary meter with cock open, or a prepayment meter with cock open and valve apparently open, light a burner in the apartment to be shut off, and then shut meter cock. If this does not extinguish the burner, you have shut off the wrong meter, and should at once turn it on, following carefully the instructions for turning on gas.

If an ordinary meter with meter cock closed, or a prepayment meter with cock closed or valve apparently closed, try to light a burner in the apartment to be shut off. If able to light burner, proceed as if the meter cock and the valve were open. If unable to light burner, turn gas on to the meter, following carefully the instructions for turning on gas, and again try to light burner. If you succeed, you have found the proper meter, which then should be turned off in the regular way. If you do not succeed, you have turned on the wrong meter, which should be turned off at once, and other meters turned on in the same way until the right one has been found.

In either of the above cases, after you have found the correct meter, replace the open tailpiece with a plugged tailpiece, and reconnect meter.

If you cannot get into an apartment to be shut off, and are unable, therefore, to light a burner therein, be guided by general conditions. If possible, make an examination of the meters that are turned on, and of the apartment each is supposed to supply. If you are not reasonably certain that you have properly identified the meter, do not complete the shut off, but leave all conditions as found.

If you cannot obtain any information regarding the location of the key, you may enter the cellar through a window if you find it unlocked, but do not visit other parts of the premises. Leave in the same way you entered, and report these facts on order.

Setting Meter

A set order implies an order to turn on gas. Therefore, follow rules under "Turning On Gas" when ready to turn on.

If there is no service, or if you find any other service conditions which render the setting of the meter impossible or inadvisable, explain the case to consumer. Telephone the shop if conditions require it.

If you cannot turn service cock, but can shut off gas at meter cock, set meter. If there is no meter cock, do not set meter unless service cock is shut. Determine this by loosening a plug in the cellar.

If the service supplies more than one meter, and gas is on to any of them, and it is necessary to shut off gas at curb to set meter, before doing so, obtain the consent of the consumers

concerned. If consumers will not consent, or a more convenient time is named, do no work; report facts on order. If consent is given, first shut off gas at curb, then at meter cocks, and proceed with the work.

When installing connections so that more than one meter can be set on the same service, place a meter cock on each "header" inlet connection, even though all the meters are not being set. Plug the outlet of each cock on which a meter is not set.

When setting meter, follow meter schedule for size. Because the old connections may indicate that a meter of another size was formerly set, is no reason why you should set that size.

If you believe the meter specified on order is too large, or too small, do not set it. Telephone the shop.

Set all meters within sight of, and as near as practicable to, the head of service, and so that the entire piping joining the meter and the service is visible to a person standing in front of the meter.

If a prepayment meter, set it so that the coin box will be easily accessible to the collectors, but, whenever possible, not where it will be visible from the street, nor where a thief can have access to it from the street.

Never set a meter where it will be:

Near a furnace or oven.
Subject to a sudden change in temperature.
Damaged by steam, acid fumes or dampness.
Chilled by being in a draught.
Inconvenient to reach, or to read index.
Liable to have the inlet piping covered by plaster or casing.

When the coalbin extends the whole width of the premises, the meter cannot be set within sight of the point where the service emerges through the cellar wall. In such a case, the service should, if possible, be so located that it comes through the front foundation wall into the coalbin at a point not more than six inches distant from one of the side walls of the premises, in which case the service pipe should be continued in a straight line through the coalbin into the main cellar, and on its end, in the main cellar, should be screwed the tee from which the piping extends to the meter. This service pipe should be supported at proper intervals by hooks or brackets attached to the side wall which it parallels. In case the service pipe cannot be brought through the front foundation wall within six inches of a side wall, the service pipe should not be extended straight across the coalbin, but it should terminate in the usual manner at the front foundation wall. Set meter on cellar wall, clear of the coalbin, and join service and meter by piping so located that as short a length as possible will be covered with coal, *i. e.*, have this pipe rise vertically from an ell screwed to side outlet of tee on end of service, to a point at or near ceiling, and thence extend to the point where it drops to the meter. When a meter is set in this manner, ask consumer to store the coal so that the end of the service will be accessible.

Arrange meter inlet piping so that as much of it as possible will drain back to the service.

If there is no fuel line installed, leave a 1-inch plugged outlet in meter outlet pipe, or use a cross at the bottom of house riser with a 1-inch plugged outlet, so that a possible future fuel line can be connected.

Observe the following rules for supporting meters:

When table is used, rest the meter firmly on table, or if blocking is used, carefully drive wooden wedges under the four corners of meter.

When adjustable shelf is used, after building the meter connections and before connecting meter, attach standard board supplied with shelf to the wall in a vertical position, with 40-penny wire nails, driven as close to the end of the board as is feasible. Take sufficient time to do this work, even to the extent of plugging the wall in order to get a firm hold for the nails. Place the board midway between the projected ends of the meter connections, at such a height that the center of the board will be on a line with the bottom of the meter when attached to the connections. This will insure a clear space in the center of the board for mounting the shelf, and the portion of the board extending up back of the meter will keep the meter at least 1 inch from the wall.

Do not mount the adjustable shelf on the board until the meter has been connected hand tight. Then set the adjustable part of the shelf in its middle position so as to allow equal distance of play up and down in the adjusting slot. See that the shelf is slightly to the outlet side of the meter bottom and midway between the front and back, and close up under the meter so that the bottom of the meter has a good bearing on it; then hold the shelf in position by hand to determine the position of the 1-inch round head wood screws with which to attach the shelf to the board. Tighten the adjusting nut by means of a small wrench or pliers.

When two or more meters are set side by side, use a separate shelf or table for each meter.

When meter is in position, see that it is plumb and parallel to wall with at least 1 inch clearance.

To avoid placing a strain on the meter, the following rules should be observed:

(*a*) See that inlet connection where it drops to meter, is as nearly perpendicular as you can sight it, and so placed as to height and distance from wall that it is in proper position to receive the meter.

(*b*) Measure the distance between the screws of the meter to be set, thus locating the point at which the outlet swivel will be placed; then build the outlet connection so that the swivel will come as close as possible to that point. If the meter is to be supported on a table on the floor, or on a special bracket already in place, it may be placed in position and the screws used as points to which the connection should be built. Place the washers on the tailpieces of the meter connections, attach meter

to the connections, making up the unions hand tight, and let it hang while you are setting the meter shelf, as described above.

(*c*) Make the standard orifice test (Test A, page 503) before attaching the meter permanently to the outlet connection. To make this test, loosen the inlet union, but do not entirely unscrew it, and unscrew the outlet union.

If tie-in connection is used, drop the outlet side of the board under meter to allow the top of the meter screw to pass under the lip of the swivel, using care to see that the weight of the meter is supported at the inlet side by the shelf. Swing meter out far enough to put on test cap. Tighten inlet union by hand and proceed with test. After completing test, remove test cap, loosen inlet union, and swing meter back into position. Then tighten both unions, first by hand, and then by using a small wrench. Clamp board firmly under bottom of meter by means of the wing nuts on the hangers.

If meter is supported other than by tie-in connection, do not lower support, but raise the outlet connection to allow the top of meter screw to pass under the lip of the swivel. Move outlet side of meter toward you enough to enable you to put on test cap. Tighten inlet union and proceed with test. After completing test, remove test cap, loosen inlet union, and turn meter so as to slip the outlet screw into position raising the outlet connection slightly if necessary. Then tighten the unions. When finally tightening the unions, tighten the inlet and outlet connections alternately. Be careful not to use any great strength or exert any sudden pull. This is unnecessary, as a gas-tight joint can be made with little pressure when the unions are properly faced. Any undue or sudden strain is likely to cause a leak at the meter screw where soldered to the meter.

If the service is an old one, test it under a pressure of 6 inches of water, after connecting meter, in order to be sure there is no leak. Apply the pressure at tee on the end of the service, after making sure that service and meter cocks are shut. Report on order, "Service tested O. K."

Do not set a prepayment meter unless the consumer gives you a quarter to start it. If quarter is not available, ascertain if possible when it will be, and report facts on order.

Make a visual inspection of fixtures, housepiping and fuel appliances to see if conditions are such that gas may be turned on.

Unless otherwise instructed, if you set a meter and for any reason cannot leave gas on, remove meter.

Removing Meter

When working on a remove order, if you find the gas on, notify the consumer before shutting it off.

If the service supplies only one meter, follow rule already given for shutting off gas.

If service cock will not turn, shut meter cock and remove meter.

If service supplies more than one meter, and gas is off at every meter except the one specified on order, shut off gas at meter and curb, remove meter, and treat the connections as described below.

If service supplies more than one meter, and gas is not off at every meter except the one specified on order, follow the rules already given, to determine the correct meter. If either connection is iron, remove swivel (whether open or plugged) and insert a plug.

When removing meter, leave shelf backboard in position, but remove adjustable brackets and turn in to shop.

As soon as you remove meter from the shelf, place metal caps on the inlet and outlet screws.

Changing Meter

A change order is equivalent to a remove and set order; therefore, in general, the rules covering removing and setting meters also apply to change orders, and should be followed when work covered by these rules is required.

When you change a meter, leave gas as found, and state on order how you found it.

When changing a meter, follow meter schedule for size to set.

CHAPTER L

TESTING AND REPAIRING

Removal

Periodic Removal

A meter, like any other mechanism, is subject to disarrangement and deterioration. Experience has shown that a periodic removal of all meters is requisite to insure the maximum of correct registration and performance, and that, in addition, the ultimate life of the meter is thus prolonged. While it would be possible by a test in place to obtain information sufficiently accurate to govern the future treatment of many of the meters so tested, the advantages of obtaining a correct registration test are so highly valued that it is universal practice (with some exceptions for large sizes) to bring all meters to a special shop for this test.

The exact interval between periodic removals has varied somewhat as between sizes of meters and also according to individual ideas. Until very recently, no attempt was made to classify the result of meter examinations or of tests according to the years elapsing since the last test. Manifestly if such a record was available, and it indicated, for any situation, that up to, say, six years of service there was little, if any, difference in the registration errors, and that these and other meter conditions did not warrant removal more often than every seventh year, the company following this practice would be able to justify it. In the absence of such data, many companies, in their desire to omit nothing that might conduce to good service, adopted an interval of three years, and in some cases, for large meters, of one year only. A few state commissions have made such a three-year removal obligatory, but more have adopted the more sensible figure of five years. This may well be accepted until further data indicate that most of the meters so removed register within correct limits and are otherwise in good condition.

Philadelphia for some years classified all tests by years in service, and, as a result, came to a seven-year interval. This was superseded by the five-year removal rule of the Pennsylvania Public Service Commission, and since this put an end to the chance of getting records based on more than five years' service, all classification ceased, not, however, before it was shown that the average net error (slow) of all the "dipping" meters removed and tested was practically independent of the time in service.

In 1915, the practice was started of soldering a date badge on the front gallery plate (left-hand side of Figure 109, page 420) of each new meter and of each meter receiving a new diaphragm repair. The purpose is to examine the diaphragms in each removed meter which this date badge shows has had ten years of service. Time alone can prove the value of such a record and practice.

Irregular Removal

While the large majority of meters may safely stay in service until removed for periodic test, there is a minority, usually few in percentage, though large absolutely in a big city, that for reasons, due to the meter itself, must be removed after a shorter service. One of the reasons for such summary removal is a disarrangement of parts, stopping the flow of gas, and this would promptly be called to the company's attention by the consumer deprived of his supply. Another is a partial or complete failure to register the gas consumed. Many honest consumers might not realize this condition, even though the registration was much below the proper figure. To meet this contingency and, at the same time, to get a fair idea of the condition of the meters visited, a test in place, known as the gradual-cease-house-test, has been used with success in Philadelphia for many years.

After every meter-reading period, a gradual-cease-house-test order is issued for each meter where the consumption is 33 per cent below that of the corresponding period of the previous year. The test is made substantially as follows:

> If the meter is a 3, 5 or 10-lt., light an open-flame burner, preferably the one nearest the meter, and turn the cock on full. Watch test hand as per table below:
>
> | Size of Proving Head | Maximum Test Hand | Time to Watch Extra Test Hand |
> |---|---|---|
> | 2 cu. ft. | 2 min. | ½ min. |
> | 5 " " | 3 " | ½ " |
>
> Report on order if the hand does not move. If the hand moves within the maximum time, turn flame

down to about $1\frac{1}{2}$ inches and watch test hand for a movement during not more than 10 minutes. Be sure that all other burners are shut.

If the meter is a 5-A to 60-A inclusive, or a 20 to 100-lt. inclusive, shut meter cock, disconnect meter outlet, turn on meter cock, allowing meter to purge for about four seconds, screw gradual-cease-house-test cap (Figure 59, page 187) on meter outlet screw, and watch test hand as per table below when using large hole (6 cubic feet per hour) in the test cap:

Size of Proving Head	Maximum Time to Watch	
	Test Hand	Extra Test Hand
2 cu. ft.	2 min.	$\frac{1}{2}$ min.
5 " "	3 "	$\frac{1}{2}$ "
10 " "	9 "	1 "
20 " "	15 "	$1\frac{1}{2}$ "

If the hand moves within the maximum time, screw on the cap with small hole (3 cubic feet per hour) and watch test hand for not more than 10 minutes.

If the meter is 150-lt. or larger, use 6 cu. ft. turn-on test cap. Watch test hand as per table below:

Size of Proving Head	Maximum Time to Watch	
	Test Hand	Extra Test Hand
50 cu. ft.	30 min.	3 min.
100 " "	60 "	—

If there is no movement of the particular test hand within the time designated, it is considered proven that the meter is out of order and is not registering correctly, and it is brought in for test and repair. If movement occurs, a report to that effect is made, and, as a rule, the meter is not changed. In the last ten years, over 220,000 of these tests have been made, and 25 per cent of the meters tested have been removed.

A third reason for summary removal is a belief on the part of the consumer that his meter is fast, i. e., registering too much gas. In such a case he almost always has the choice of a test by the company or one by a state or city official. The official test usually requires the payment of a small fee, which is refunded in case the meter is fast. The records of many years throughout this country all tell the same story of very few demands for official tests, and of a large percentage of these tests showing meters correct or slow.

In one city a special study has been made, for many years, of the meters so removed for official test, and this is summarized

below, as it shows very clearly the effect on registration of the various ills to which a meter may be subject:

FAST METERS

Condition	Causing	Result
Diaphragm dry or hard	Restricted stroke of diaphragm	Reduction in the volume of gas passed per revolution of the tangent
Flag arm out of division	Valve cut off before diaphragm stroke is completed	Reduction in the volume of gas passed per revolution of the tangent
Liquid in excess	Reduction in diaphragm capacity	Reduction in the volume of gas passed per revolution of the tangent
Packing loose in stuffing box	Reduction in pressure drop necessary to operate meter and hence in diaphragm capacity	Reduction in the volume of gas passed per revolution of the tangent

SLOW METERS

Condition	Causing	Result
Bridge loose at base	Crank to wobble, thus increasing diaphragm stroke	Increase in the volume of gas passed per revolution of the tangent
Diaphragm water soaked	Extra resistance, hence increase in pressure drop necessary to operate meter, stretching diaphragm	Increase in the volume of gas passed per revolution of the tangent
Packing jammed in stuffing box	Extra resistance, hence increase in pressure drop necessary to operate meter, stretching diaphragm	Increase in the volume of gas passed per revolution of the tangent
Valve dirty	Extra resistance, hence increase in pressure drop necessary to operate meter, stretching diaphragm	Increase in the volume of gas passed per revolution of the tangent
Diaphragm broken at tying or with holes	Flow of gas without movement of meter parts	Partial failure to measure
Valve leaking	Flow of gas without movement of meter parts	Partial failure to measure
Valve guide broken and valve off seat	Flow of gas without movement of meter parts	Entire failure to measure

None of the conditions shown as resulting in fast meters is very common, and the most frequent one, which is the drying or hardening of the diaphragm, may be almost completely prevented in the "dipping" meter. On the other hand, the longer a meter stays in service, the more apt it is to develop one of the ills which will make it slow. Therefore, it is the company and not the consumer that suffers from the lack of any periodic removal.

Returning to other reasons that may exist for the removal of meters at irregular periods, all of these reasons (including the ones already described and the periodic removals) may be listed under four major heads as given below, which are records of yearly removals based on an average of ten years:

Cause of Removal	Percentage of Total Meters Removed	Percentage of Total Meters In Use
Defects due to meter itself	38.9	9.2
Defects due to surrounding conditions	8.1	1.9
Desire of consumer	31.7	7.4
Policy of company	21.3	5.0
	100.0	23.5

The large figure opposite "Desire of consumer" is due to the fact that in this situation there are many prepayment meters, and at all times numerous consumers are changing from ordinary to prepayment, or vice versa. "Policy of company" represents, almost entirely, periodic removals. Included in these are meters which have been shut off for two years in consumers' houses. The practice of allowing these meters to be shut off, rather than removed at the time the house is vacated, is justified by years of local experience, which shows that so many of these meters are turned on again within two years that the saving in operating costs, through the lessened removals and subsequent re-sets, is considerably more than the expense of turning on and the interest on the idle meter investment.

As a result of all the reasons for irregular removal, it is probable that even where there are few or no changes in kind of meter, from ten to twelve per cent of all the meters in use are brought in each year. Since all of these meters are tested for accuracy of registration, and many are given an additional examination, it is manifest that there is ample material available for the previously described classification of meter behavior by years of service.

Dipping Process

Value of Process

The description of the principle of measurement on page 417 clearly shows how one essential to correct registration is the displacement of a constant volume by the motion of the diaphragm disc. This, in turn, depends upon preserving unchanged the shape and flexibility of the leather diaphragm. Unfortunately, observation has long taught that after more or less service, many diaphragms become deprived of the oil with which they are saturated when placed in a meter, and are found to be in a bleached condition, with the leather dry or hard, resulting in a fast meter, as previously noted.

Investigation has shown that whenever the temperature of the meter interior is lower than that of the entering gas, some of the

oil vapors in the gas will condense on the diaphragms and wash out any of the original oil still remaining in the leather. Therefore, the diaphragm oil may be rapidly thinned and drained out of the leather, leaving the latter saturated with merely the volatile vapors condensed from the gas. If when in this condition the meter temperature gets above that of the entering gas, evaporation of these vapors follows and the leather becomes dry and somewhat porous, stiff and shrunken. During its remaining service, the leather will be unprotected by any diaphragm oil, and the registration of the meter will vary according to the degree of saturation of the leather with vapors deposited out of the gas.

This condition, usually known as bleached diaphragms, became especially aggravated in Philadelphia about 1905, with the use of Texas oil in gas making. After a good deal of thought and experimental work, a simple remedy was discovered, which, after ten years of application, is giving satisfactory results in more than a million meters in different cities. This remedy depends upon the capillarity of the leather, and consists in placing sufficient oil in the bottom of the meter to immerse the diaphragm to a depth of at least $\frac{5}{16}$-inch. Under such conditions, the leather remains soaked with this oil, except for comparatively brief periods when oil vapors from the gas are being deposited and are washing out the diaphragm oil. Even then, the leather being wet with the condensed vapors, tends to keep its shape, and therefore, the meter registration unchanged. As the oil vapors dry out, a fresh supply of diaphragm oil ascends all through the leather.

A meter so oiled is known as a dipping meter. A fuller description of the reasons leading to, and the advantages of, the dipping process are contained in "Causes of Variation in Proof of Consumers' Meters," a paper by J. M. Rusby, as printed on page 354 of the 1906 Proceedings of the American Gas Institute.

Oil Used

The oil used in Philadelphia is known as No. 4 Neutral oil. Its properties are indicated by the following data:

	Early Samples	Recent Samples
Specific gravity	.870	.866
Congealing point	35° to 38° F.	12° F.
Viscosity (P. R. R. pipette)	1.9 at 100° F.	1.66

The oil has a strong affinity for the hydrocarbon vapors in the gas, and in its first three or four months of service will absorb

these vapors to the extent of about 12 per cent of its own volume. After that, a saturated condition appears to be obtained and absorption ceases. A very small per cent of absorption lowers the congealing point considerably. Any oil drained from a meter is disposed of with other condensation, and new oil supplied for the re-oiling process.

At this point it might be stated that several companies using the dipping process and making their own diaphragms, have replaced the special diaphragm oil formerly used on new diaphragms, with the neutral oil, it being obvious that since the diaphragm would, after a few months of life, lose the diaphragm oil and absorb the neutral oil, there was no advantage in handling two kinds of oil in the repair shop.

Introduction of Oil

It has been found perfectly feasible to introduce oil into meters brought in from service without removing any part of the case, and the meter so oiled may be put back into use with perfect assurance that its condition has been improved. This ability to convert into dipping meters, at very slight expense, every meter brought in from service, materially cheapens such a change of all the meters in any situation. In this way, Philadelphia converted about 400,000 meters in twelve years.

In following such a plan of conversion, the meters become divided into three classes:

Class 1. Meters not yet converted, known as nondipping meters.

Class 2. (*a*) Meters, the clearance of whose diaphragm off the bottom of the case is not definitely known. Such are usually all meters brought in from service into which oil is put without first removing front and back plates. The only exception would be meters known to have been equipped with diaphragms of definite dimensions.

(*b*) Meters whose diaphragm clearance is more than $\frac{3}{16}$- and not over $\frac{3}{4}$-inch.

(*c*) Meters, comparatively rare, whose diaphragm clearance is more than $\frac{3}{4}$-inch. They have an additional designating mark, and a record is kept of the oil put in, for use if subsequent re-oiling occurs without exposure of the diaphragms.

All Class 2 meters are known as dippers, and are identified by the use of roundheaded rivets in the drain holes.

Class 3. Meters whose diaphragm clearance is $\frac{3}{16}$-inch or less, as determined at the time of putting in new or cleaning old diaphragms. These are also known as dippers, and are identified by the use of flathead rivets.

Figure 158—Draining Meter, page 521.

The instructions for the introduction of oil are as follows:

Remove any liquid from the columns by the small hand pump (B, Figure 70, page 203). Lay the meter on the inlet side, and, with a long taper shoulder punch

and a light hammer, make, in the outlet side, two $\frac{1}{4}$-inch holes, each $\frac{3}{4}$-inch above the bottom and midway between the center partition and the outside of the meter. Use a scribe, properly set to mark the height above the bottom, to insure uniformity and the clearance of any bottom flange. Lay the meter

Figure 159—Oiling Meter, page 521.

on the outlet side, and allow the condensation to drain out of the diaphragm chamber through the two holes, Figure 158. Then reverse the meter and, by the use of funnels of special design inserted in the holes, pour into each diaphragm chamber the amount of oil required by the particular meter in question, Figure 159. After the removal of the funnels, scrape

clean of paint and wipe dry the surface within $\frac{1}{2}$-inch of each drain hole. Insert a tinned rivet in each hole and lightly tap it home. Sweat each rivet in position with a rather cool soldering iron, and make a neat job by finishing around each head with the iron. If the tin coating around the drain holes is defective, re-tin before inserting the rivet. Emphasis is laid on these details of closing the drain holes, as carelessness in this regard will result in oil leaks,— a source of expense to the company and of annoyance to the consumer.

It has been stated before that it is desired that each diaphragm should be immersed at least $\frac{5}{16}$-inch. Therefore, the amount of oil required by any meter depends not only upon the area of its cross section, but also upon the clearance of its diaphragm. In the following table, the oil for 3-, 5-, 10- and 30-lt. meters is based, for Class 2, on an assumption of $\frac{3}{4}$-inch, and for Class 3 on $\frac{3}{16}$-inch clearance. For all the other sizes the diaphragms are assumed to be touching the bottom. Therefore, all the meters of this class are sure to have sufficient immersion except Class 2 (c) until the latter has been opened and properly marked.

Size of Meter	Ounces of Oil	
	Class 2	Class 3
3-lt.	20	10
5-lt.	24	10
10-lt.	34	16
20-lt.	22	22
30-lt.	68	32
45-lt.	38	38
60-lt.	47	47
100-lt.	60	60
150-lt.	98	98
200-lt.	98	98
300-lt.	124	124
5-A	—	10
10-A	—	16
30-A	—	32
60-A	—	64
150-A	—	110

The method of determining the above quantities of oil is as follows, all dimensions being expressed in inches: Width of diaphragm chamber, times depth of chamber, times height of oil, i. e., clearance of diaphragm plus $\frac{5}{16}$-inch, divided by 1.8, equals ounces of oil required in each chamber.

Treatment after Oiling

After introducing oil into a 3, 5 or 10-lt. meter, it should be laid on its outlet side for two days, then for the same time on its inlet side, and then stood on its bottom for six days. Meters 20 to 100-lt. inclusive should be laid on their outlet side for ten days, and then for the same period on their inlet side. Racks or suitable blocking, should be employed to enabie the sides of the meters to be kept in horizontal planes. A meter should be slowly lowered on its outlet side to prevent a wave of oil reaching the valve seats. The endeavor is to insure the complete saturation of the diaphragms to permit them to attain their most permanent condition before making the check test subsequent to the introduction of the dipping oil. On this final check test, the proof usually is more nearly correct than that of the check test after removal from service, for the general effect of the oil is to make a slow meter faster, and vice versa; in other words, to bring the meter back toward the condition of correct registration

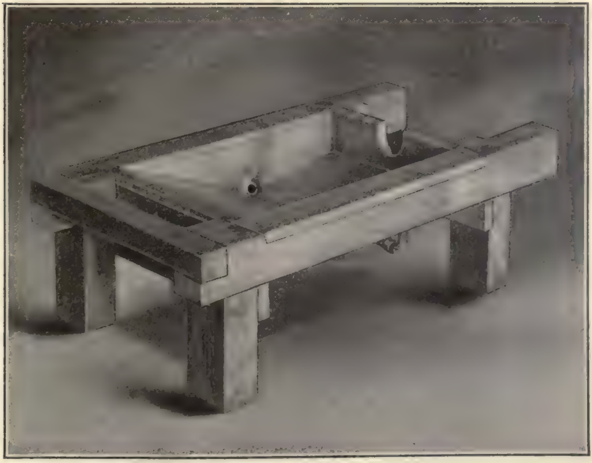


Figure 160—Draining and Oiling Table for Large Meters, page 524.

in which it was first set. A knowledge of this corrective effect of the oil permits the allowance of wider limits of error before removing the top and adjusting on the first check test.

The preceding paragraph refers only to meters into which oil is introduced the first time upon diaphragms which have not just been put in, or, being old diaphragms, have not been exposed and oiled by hand.

A careful inspection of each meter should be made for oil leaks at bottom seams, corners and rivets. To render such leaks less likely of occurrence, the bottom corners should be loaded with solder, whether or not the front and back plates are removed.

The removal of liquid from a dipping meter brought in from service may be necessary in order to make repairs locally, or prior to shipment if repairs are made elsewhere; or if the amount of liquid in the meter is thought to be excessive. The only way to determine this is by the increased weight and by shaking in order to judge by the swash. A thorough draining prior to the shipment of a meter reduces the possibility of oil finding its way to valve seats.

Equipment

The tinned rivets used have a shank $\frac{7}{32}$-inch in diameter and $\frac{1}{4}$-inch long under the head. The diameter of the flat head is $\frac{9}{16}$-inch and of the round head, $\frac{7}{16}$-inch.

The equipment found useful comprises the following articles:

3 Measuring Cups, 10-, 16- and 24-oz.,
12 Special Funnels,
2 Gauges for determining height of diaphragm, $\frac{3}{16}$- and $\frac{3}{4}$-in.,
1 Graduate,
2 Meter Column Pumps,
1 $\frac{1}{4}$-in. Shoulder Punch, with long taper,
1 Scraper,
1 Scribe for marking height of drain holes,
1 Draining and Oiling Table for small meters, Figure 159,
1 " " " " " large meters, Figure 160,
1 60-gal. Oil Tank and Pump.

Testing and Repairing

Explanatory

The interdependence of the various tests and the relation of each test to the needed repair that it may indicate, will become apparent after the different tests and repairs have been described.

It will be seen throughout that the one object underlying all meter repairing and testing, after the initial test for purposes of recording has been made, is to place in condition for re-setting, as quickly and, with reference to the ultimate life of the meter, as economically as possible, every meter brought in from service. The text will be easier to understand if frequent reference is made to the previous illustrations of the meter and its action, more particularly Figures 118 and 120, pages 431 and 438 respectively. As local conditions will determine the precise order best suited to any situation, no attempt will be made to describe an ideal procedure from the time of removal until the meter is again ready for use. The principal tests and repairs will be described separately, and this will be followed by a discussion of some considerations influencing the location chosen for this work and the order of work as now observed in Philadelphia. There will be no description in detail of the dismantling or re-assembling of a meter.

Inspection of New Meters

Before entering into the details of the work on removed meters, a few words will be said as to the precautions advisable to insure the correctness of all new meters. It has been the good fortune of the gas industry that the manufacture of the gas meter has been characterized always by high principles and skilled methods. Therefore, there is every reason to believe that a new meter, as received from the manufacturer, is in correct working order. At the same time, the gas companies, with a full appreciation of their obligation to the public, have always made certain tests of these new meters prior to placing them in service. The practice in Philadelphia is as follows:

One out of every ten meters is given the open test, consisting, as described below, of a comparison between the open and check runs, and including the check test which shows the proof of the meter. One-tenth of these meters, selected at random, are tested for capacity under a five-tenths loss in pressure, and then examined for defects in workmanship by taking off the top, front and back plate, thus exposing the working parts above the table top and the diaphragms. If the meters are over the allowable error on the check or open test, or if the diaphragms touch the bottom or sides of the compartment, or if serious defects in workmanship are discovered, the meters are returned to the makers. At one time every new meter was given the check test, and 10 per cent the open test. Experience proved, however, that the

condition of the meters as received was too good to warrant so much testing. Philadelphia is favorably situated in this

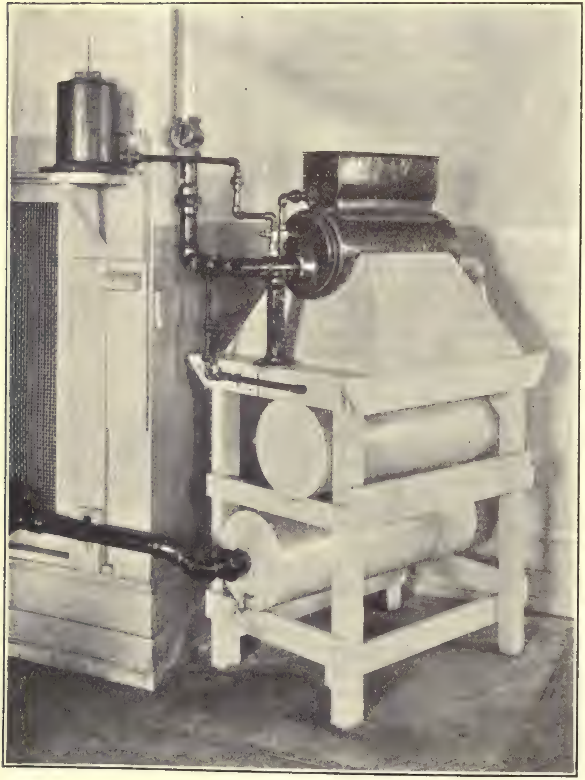


Figure 161—Saturator Showing Gas Inlet (top) and Outlet (bottom), page 527.

respect, all of its meters being made within the city and delivered by wagon. In situations receiving meters via railroad, more extensive testing will probably prove advisable.

To those who know the great care exercised to see that, at all times, both new and removed meters register correctly, the folly of governmental performance or supervision of this meter testing work, and the waste entailed thereby, are hard to contemplate calmly, and the optimist must cherish the hope that it will cease as part of a general advance in national efficiency.

Medium Used

Air has been, and still is, the medium generally used for the various tests. Drawn from the workroom, it is more convenient to use than air saturated with oil and water vapor, and much more so than gas similarly saturated. There is a growing appreciation, however, that after a meter has once been in service, its condition is affected by being brought in contact with an unsaturated medium, the tendency of which is to pick up vapors from the meter interior and hence to alter the condition of the valves and the diaphragm leather, and to undergo a change in its own volume, all of which will affect the proof of the meter.

Therefore, there is good reason for the use of saturated gas in the check test in order that the latter closely represent the working condition of the meter at the time of its disconnection, which has been preserved by the capping of the columns on removal.

Saturated gas has been used in Philadelphia since 1913 for the check test of every meter removed from service. The gas coming from the street is passed through a "saturator," a copper cylinder jacketed with hot water. Water, admitted at the inlet, and drip oil, at the outlet of the saturator, are vaporized and picked up by the gas which becomes heated in its passage through the cylinder. Tin cooling chambers are provided for reducing the temperature of the saturated gas to that of the proving room. The gas pressure is utilized for raising the prover bell. After passing through the meter, the gas escapes through ventilators. Figures 161 and 162 are two illustrations of this apparatus in an earlier form, with the drip oil admitted at the inlet.

In Philadelphia, gas is also used on meters brought in from service, for all other tests affecting diaphragms. The meter being still full of gas at the completion of the check test, the continued use of gas for additional tests obviates all danger of explosion.

It is believed that the gas as drawn from the street is less harmful to the meter than unsaturated air would be.

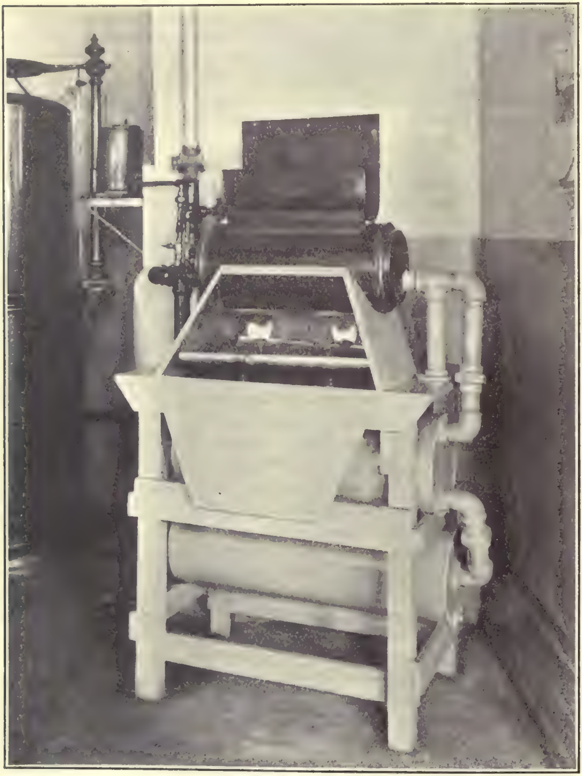


Figure 162—Saturator Showing Heating Burners under Water Jacket, page 527.

As the use of gas for the testing medium is not very common in this country, the description of the different tests will assume the use of air.

Check (or Proof) Test

Reason for Test

In discussing the reasons for removing a meter, it was stated that the principal object was "to insure the maximum of correct registration." Hence, it is obvious that the first test to be made of a removed meter is to ascertain its "proof," which is the accepted term used to designate its condition of registration. This proof test not only indicates what has been the registration history of the meter in the recent past, but also serves as a valuable diagnosis of its present condition from which to determine the necessary subsequent testing and repairing.

The check test is given to every meter removed from service. It shows the accuracy with which the meter was registering gas for the consumer at the time of removal. Its result is, therefore, of value in dealing with consumers, and in tabulating and summarizing meter tests, and also in deciding what is needed in order to fit the meter again for service. Meters testing over 10 per cent wrong are sent to the repair shop. Those under 10 per cent are given other tests at the district shops, and if they pass, they are adjusted and put into O. K. stock.

The check test is also given to all meters that have been repaired, as a part of the process of adjusting them to correct registration.

Prover

In describing, on page 417, the principle of measurement of a meter, it was shown that this consisted in filling and emptying a measure of standard volume. It easily is seen, therefore, that the accuracy of measurement may be tested by passing a known volume through the meter and noting the corresponding movement of the proving head pointer (34, Figure 120, page 438).

The apparatus for this purpose is called a "meter prover," Figure 163. There is a metal tank, 1, filled with water, which acts as a seal to prevent the escape of gas or air from the prover bell, 2, a hollow metal cylinder with a dome-shaped top and no bottom, guided between three columns as it rises out of or descends into the water. It is raised by pulling down on the grip, 3, communicating by the chain, 4, over the wheel, 5, with the top of the bell. A counterbalance weight, 6, is supported from the cycloid, 7, and thus the pressure thrown by the bell

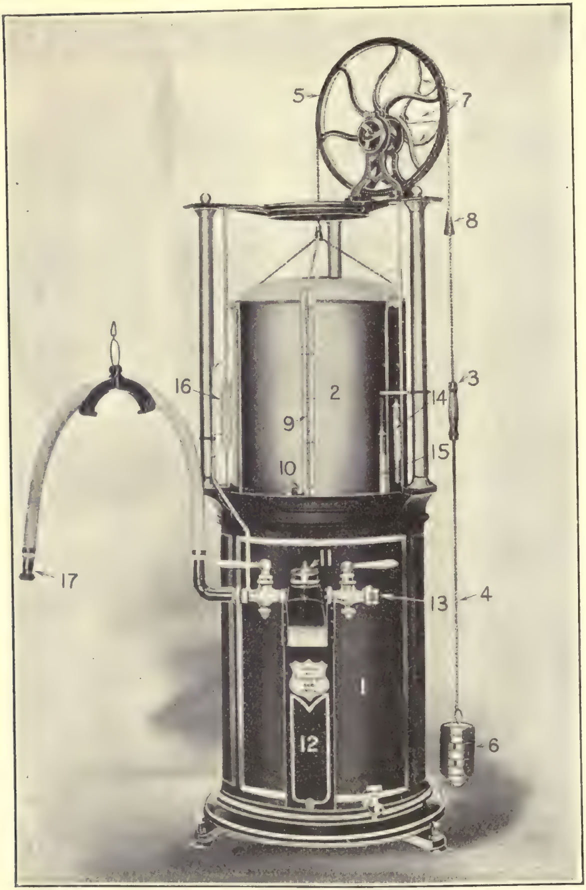


Figure 163—Meter Prover, page 529.

remains constant, being made independent of the extent of immersion. The amount of this pressure is determined by the weight of the counterbalance, and usually is 1.5 inches. The capacity of the bell, from a careful determination, is marked in cubic feet and decimal fractions on the vertical scale, 9. This scale, in connection with the pointer, 10, projecting from the tank top, enables an accurate measurement of the volume passing out of the bell as it descends into the tank. A revolving valve, 11, communicates with the interior of the bell by the pipe, 12, on which there are two outlet cocks, 13, so that the meter to be proved may be placed either to the right or left of the tank. From the cock, piping and rubber hose form the connection to the meter. One thermometer, 14, measures the air temperature at the prover, and another, 15, that of the water. A pressure gauge, 16, connected beyond the outlet cock, shows the pressure maintained during the test.

For a small company, a prover with a bell capacity of five cubic feet is recommended. A large company, or one owning meters larger than 100-lt., will need a 10-foot size. A copper bell and brass tank will prove most economical in the long run. It is general practice to calibrate each prover at regular intervals against a standard cubic foot bottle. Details of this operation and of the use of meter proving apparatus are given in Pamphlet No. 48 of the Bureau of Standards.

Meter Condition

The desire in proving a meter being to test it under as close to actual operating conditions as possible, it is tightly capped (see page 512) on removal. It also should be handled carefully and kept upright to prevent any change in interior conditions. On its receipt at the prover room, it should be placed above the floor and out of drafts, and allowed to stand at least five hours, and preferably over night, before testing, in order that its interior may attain the oom temperature. Under ordinary circumstances, any further delay will only tend to increase the chance of a change in meter condition, so a safe rule to follow is to test not later than the next working day after receipt. This point of allowing sufficient but not excessive time between receipt and proving, is emphasized, as in the past not enough attention has been paid to this requirement by some companies, and carelessness in this respect gives tests of no reliability.

Temperature Requirements

As a difference of 5 degrees in temperature causes a change of about 1 per cent in the volume of a gas, it is essential that there be on change in the temperature of the measuring medium from the time that it leaves the prover bell until it has passed through the meter. To meet this requirement, the temperature of the air in the room, at the prover, and of the water in the prover should not differ by more than one degree. The thermometers used to measure these respective temperatures should be checked against a standard thermometer and each other annually, and the working thermometers should agree within one degree throughout the range between 60° and 100° F.

The ideal temperature of a proving room is the standard one of 62° F., but practically the only requirement is the uniformity just described. Proper maintenance of the room temperature may be obtained by adequate heating facilities and construction. It is clear that there never should be a rapid change in this temperature, for this would complicate excessively the task of keeping room, water and meter temperatures the same. The location of the prover must also be chosen so that the surrounding air will be uniform in temperature with that of the rest of the room.

To control the water temperature most conveniently involves the ability to deliver into the prover tank either hot or cold water. Both supplies and the draw-off connection should enter at the bottom. After any change of water, the entire contents should be agitated until the temperature is the same throughout.

The use of water in the tank introduces a slight source of error through temperature changes. As the bell rises, water clings to both outer and inner surfaces. Evaporation from these films and, to a lesser extent, from the water surface within the bell, lowers the temperature of the adjoining air, and, therefore, of the bell contents. If the latter is used immediately, this will result in a slight expansion of the measuring medium as it passes through the meter, because the latter is at the general room temperature, and this change in volume during the passage from the bell through the meter is the cause of the error already alluded to. This may be avoided by placing upon the surface of the water, a 4-inch layer composed of a mixture of $1\frac{1}{2}$ parts of No. 4 Neutral and 1 part of "long-time burner" oil. As the bell rises, it is coated with an oil film, the evaporation from which may be disregarded because of its low vapor tension. The mixture is also sufficiently viscous to adhere to the bell surfaces

for a considerable time after submergence, so a prover in constant use is uniformly oil coated. The prover bell should be filled, at all times, when not in use. Each morning the outside surface of the bell should be wiped, using clean muslin or cheesecloth, with a light upward stroke. If the surface is of polished metal, it should be rubbed lightly once a month with a good metal polish, and a very thin film of polish left on.

Rate of Flow

The rate of flow of the measuring medium is controlled by an opening in a cap screwed on the meter outlet. The theory underlying the adoption of any rate is that it should approximate the average conditions under which the meter actually operated. The assumptions of former years, which unfortunately have been embodied in the regulations of many states and municipalities, resulted in the adoption, for each size meter, of an opening that, with a pressure of 1.5 inches at the inlet, would pass per hour, 6 cubic feet for each *light* of the meter, this being what was formerly considered the meter capacity. Column C of the table, Figure 164, shows, for each size meter, what the test rate would be according to this rule. For comparison, in Column B is given the actual capacity under five-tenths loss, and it is thus apparent that the test rate for the smaller sizes is but a small per cent of the capacity, gradually increasing to practically 100 per cent in the larger. Therefore, consistency demands either a lowering of the latter rates or a raising of the former. As experience teaches that in these days of increasing uses for gas, the smaller meters are more apt to be worked to capacity than the larger ones, then to make the test rate approximate the condition of use, figures as given in Columns D or E, which roughly represent the capacity under three-tenths loss, should be adopted. Column D, which is Philadelphia practice, accepts the 6-cubic-foot per light rate for meters 20-lt. and larger. However, in testing "A" meters at the same rate as the corresponding case size, it is not consistent, and in this respect the practice of some other companies, as shown in Column E, otherwise much the same, is preferable. Column F shows the approximate diameter of the openings in the caps used by tehse companies.

It has been stated twice previously that the test rate should *approximate* the former operating conditions. Of course, these conditions vary greatly, even for the same size of meter, for different conditions of use. One meter may work for many hours at a very slow rate, and for a short time at such a high rate that

the majority of the consumption is thus registered. In another meter the conditions will be reversed, and in still others will exist all conditions between these two extremes. Therefore, as the actual operating conditions are never known, the weight of expert

A	B	C	D	E	F
		Check Test Rates			
Size of Meter	Capacity .05 Loss	At 6 Ft. per Light	Philadelphia Practice	Certain Other Companies	*Approximate Diameter of Opening in Cap
3-lt.	65	18	40	30	$\frac{5}{32}''$
5-lt.	90	30	50	40	$\frac{11}{64}''$
5-A	175	—	50	100	$\frac{19}{64}''$
10-lt.	140	60	80	70	$\frac{15}{64}''$
10-A	375	—	80	215	$\frac{7}{16}''$
20-lt.	200	120	120	100	$\frac{19}{64}''$
30-lt.	280	180	180	160	$\frac{25}{64}''$
30-A	875	—	180	575	$\frac{23}{32}''$
45-lt.	315	270	270	215	$\frac{7}{16}''$
60-lt.	475	360	360	330	$\frac{17}{32}''$
60-A	1500	—	360	800	$\frac{27}{32}''$
100-lt.	600	600	600	575	$\frac{23}{32}''$
150-lt.	1015	900	900	800	$\frac{27}{32}''$
150-A	3400	—	900	1500	$1\frac{3}{16}''$
200-lt.	1380	1200	1000	1000	$1''$
300-lt.	1635	1800	1500	1500	$1\frac{3}{16}''$

* Thickness of brass at opening, $\frac{1}{16}$ to $\frac{1}{8}$-inch.

Figure 164. Check Test Rates, page 533.

opinion is against testing at more than one rate, holding that the extra expense involved is not warranted, because it is impossible to prove that greater accuracy results from testing at two or more rates.

Test Procedure

The meter inlet screw is connected to the union at the end of the rubber hose, 17, Figure 163. The washer should be clean and in good condition, and excessive tightening of the union avoided, as this is more apt to cause leaks than to stop them. When the check test is being made during the repair of a meter, and the inlet screw is missing, the right sized screw should be connected to the hose, the shank inserted in the meter column and putty used for a tight joint. A cone-shaped tin tube should not be

used at this time, as it might cut down the flow below the check test rate.

It is, of course, absolutely essential that all of the air that comes out of the prover bell passes through the meter outlet; in other words, that no leaks exist in the meter or its connection to the prover. To test this, the outlet cock is opened, and when air issues freely from the meter outlet, the latter is covered tightly by the palm of the hand and the cock shut. If the pressure in the gauge drops, there is a leak somewhere beyond the outlet cock, to be found and stopped. Were the test made by covering the outlet as soon as the cock was opened, the pressure gauge might indicate no leak, and yet one might exist in the meter and not be evident, because the meter was stuck and the leak would not show before motion took place.

When the pressure test is satisfied, enough air should be sent through the meter to set it moving freely, after its day of inaction and to insure the same temperature in the meter as in the prover. When meters undergoing repair are being tested with the tops off, it is found that at least three revolutions of the tangent arm are required. In the check test being described, the top is on and, therefore, the motion of the tangent arm is not visible, but an experienced workman knows instinctively when the meter reaches a normal working condition. Then the check test cap is screwed on the meter outlet and air passed through until the proving head pointer (better known in this connection as the test hand) is over one of the divisions of the proving head circle. There has been, and still is, a difference of opinion whether the test should start at the bottom, top or side of the circle, and if the latter, on the up or down stroke. If the meter mechanism had no backlash or lost motion, the choice of the starting point could have no effect on the result of the test, but to avoid these sources of error, the side position is most in favor, with the weight of authority favoring the up stroke. The purpose of screwing on the check test cap before the test hand is brought to the starting point, is to bring the meter to a moderate speed before the test begins.

The test hand being over the proper division, the bell of the prover is raised until the zero mark of the vertical scale is slightly above the pointer. Then, by careful handling of the revolving valve, air is let out of the bell until the zero is just opposite the pointer. At this stage, all the preliminaries are complete, and with the opening of the outlet cock begins the proof test, which

is a measurement in two different ways of the same volume of air. The first, which is also the standard measurement, is the amount which goes out of the prover bell, as shown by the movement of the vertical scale down past the pointer. The second, which is the measurement being tested, is the registration of the test hand by its movement over the proving head circle. Because the divisions on the circle are few and those on the scale numerous, it is necessary to end the test after one or more complete revolutions of the test hand, and by reading the exact position of the pointer on the scale, determine the character and extent of any error in registration, as hereinafter explained. Therefore, when the test hand has reached its starting point, the outlet cock is closed. Too much stress cannot be laid on the necessity for great accuracy in the start and stop of a test with reference to the position of the test hand over the division of the proving head circle and the prover pointer over the zero of the scale. Until practice enables speed without the sacrifice of accuracy, the workman should resist any temptation to fast work.

In making a check test with the top off, the position of the tangent arm, and not of the test hand, is the guide. The outlet cock is closed when the tangent arm has made the nearest number of complete revolutions corresponding to one revolution of the test hand. Such a test avoids any error due to lost motion in the gearing.

Theoretically, the effect on the test result of the error of observation for the correct position of the test hand at starting and stopping, will be diminished in proportion to the number of revolutions of the test hand included in one test, and, therefore, some companies make two revolutions. There is plenty of experience, however, to show that results of equal commercial accuracy are possible with one revolution, and so due regard for economy of time (and where gas is used, of material) should make this the practice, especially in large situations.

With the same idea of obtaining increased accuracy, it is argued that the proof of the meter should be based on the average of two or more tests or "runs." What should be considered as the determining objection to this proposal and the convincing reason for one run only, is that with the use of unsaturated air, the condition of the meter changes with each run, and, therefore, the average of more than one run is not nearer to, but further from, the true condition of the meter as it was when in service, than is the result obtained from the first run. Ordinarily, each

run gives a result "faster" than the one preceding, for as the vapors are absorbed from the diaphragm, it becomes dry and tends to shrink. (See the first "condition" under "Fast Meters," page 516). This change in the meter, due to the absorption of vapors, has been previously referred to in giving the reasons for the use of saturated gas. When employing the latter medium, repeated runs are unnecessary because the result of each run is the same, due to the unchanged meter condition.

Report of Results

At the conclusion of a check test, these facts are known: The test hand has made one or more complete revolutions equalling a whole number of cubic feet, while the prover bell has moved down a distance, amounting to, as shown on the scale, either more or less than the volume indicated by the test hand. This on the supposition that the meter is not correct, but either fast or slow, *viz.*, registers either more or less than the true amount. Let us assume that the test hand moved 2 feet and the prover 1.96 feet ("cubic" is omitted for brevity). Then the error of the meter expressed as a percentage of the volume actually passing out of the prover, would be $\frac{(2.00-1.96)\times 100}{1.96}=2.04$ per cent fast. This expression of the result as a percentage of the volume actually *delivered*, hereafter referred to as Method "D," gives the only correct indication of the accuracy of registration and would be universally followed were it not for two conditions. The first is as mentioned before, that the few divisions on, and the small size of, the proving head circle make it necessary to stop a test after a whole number of feet have been registered by the meter, so that if the meter is in error, a fraction more or less of this number of feet has passed out of the prover. Thus, the volume *registered* is a whole number, while the true volume, which is the volume *passed*, can only be expressed by the aid of fractions or decimals. This has a tendency to make the volume *registered* (in the example cited, 2.0 feet) be regarded as the standard and the meter considered $\frac{(2.00-1.96)}{2.00}\times 100=2.00$ per cent fast. This expression of the test result will be called Method "R." If it were possible to end a test after 2 feet had gone out of the prover, and then read the position of the test hand

to the nearest hundredth, the reading being 2.04, the result $\frac{(2.04-2.00)}{2.00}\times 100=2.00$ per cent fast (Method "D"), would never have to yield to $\frac{(2.04-2.00)}{2.04}\times 100=1.96$ per cent fast (Method "R").

FEET PASSED ACCORDING TO PROVER	PERCENT OF ERROR	FEET PASSED ACCORDING TO PROVER	PERCENT OF ERROR	FEET PASSED ACCORDING TO PROVER	PERCENT OF ERROR	FEET PASSED ACCORDING TO PROVER	PERCENT OF ERROR
1.60	+25.0	1.87	+7.0	2.14	-6.5	2.41	-17.0
1.61	+24.2	1.88	+6.4	2.15	-7.0	2.42	-17.3
1.62	+23.4	1.89	+5.8	2.16	-7.4	2.43	-17.7
1.63	+22.7	1.90	+5.3	2.17	-7.8	2.44	-18.0
1.64	+21.9	1.91	+4.7	2.18	-8.3	2.45	-18.4
1.65	+21.2	1.92	+4.2	2.19	-8.7	2.46	-18.7
1.66	+20.5	1.93	+3.6	2.20	-9.1	2.47	-19.0
1.67	+19.7	1.94	+3.1	2.21	-9.5	2.48	-19.4
1.68	+19.0	1.95	+2.6	2.22	-9.9	2.49	-19.7
1.69	+18.3	1.96	+2.0	2.23	-10.3	2.50	-20.0
1.70	+17.6	1.97	+1.5	2.24	-10.7	2.51	-20.3
1.71	+17.0	1.98	+1.0	2.25	-11.1	2.52	-20.6
1.72	+16.2	1.99	+0.5	2.26	-11.5	2.53	-20.9
1.73	+15.6	2.00	±0.0	2.27	-11.9	2.54	-21.3
1.74	+14.9	2.01	-0.5	2.28	-12.3	2.55	-21.5
1.75	+14.3	2.02	-1.0	2.29	-12.7	2.56	-21.9
1.76	+13.6	2.03	-1.5	2.30	-13.2	2.57	-22.2
1.77	+13.0	2.04	-2.0	2.31	-13.4	2.58	-22.5
1.78	+12.4	2.05	-2.4	2.32	-13.8	2.59	-22.8
1.79	+11.7	2.06	-2.9	2.33	-14.2	2.60	-23.1
1.80	+11.1	2.07	-3.4	2.34	-14.5	2.61	-23.4
1.81	+10.5	2.08	-3.9	2.35	-14.9	2.62	-23.7
1.82	+9.9	2.09	-4.3	2.36	-15.2	2.63	-24.0
1.83	+9.3	2.10	-4.8	2.37	-15.6	2.64	-24.2
1.84	+8.7	2.11	-5.2	2.38	-16.0	2.65	-24.5
1.85	+8.1	2.12	-5.7	2.39	-16.3	2.66	-24.8
1.86	+7.5	2.13	-6.1	2.40	-16.7	2.67	-25.1

Figure 165—Percentage of Error Table—2 Cu. Ft. Proving Head. **page 542.**

The foregoing reason is purely psychological and may influence only a few of those who follow Method "R." The more practical reason is that *when* the result of a proof test is to form the basis of an adjustment of the charge for an amount of gas registered by the meter under test, then the amount *registered* becomes the

FEET PASSED ACCORDING TO PROVER	PERCENT OF ERROR	FEET PASSED ACCORDING TO PROVER	PERCENT OF ERROR	FEET PASSED ACCORDING TO PROVER	PERCENT OF ERROR	FEET PASSED ACCORDING TO PROVER	PERCENT OF ERROR
4.50	+11.1	4.79	+4.4	5.08	-1.6	5.37	-6.9
4.51	+10.9	4.80	+4.2	5.09	-1.8	5.38	-7.0
4.52	+10.6	4.81	+4.0	5.10	-2.0	5.39	-7.2
4.53	+10.4	4.82	+3.7	5.11	-2.2	5.40	-7.4
4.54	+10.1	4.83	+3.5	5.12	-2.3	5.41	-7.6
4.55	+9.9	4.84	+3.3	5.13	-2.5	5.42	-7.8
4.56	+9.7	4.85	+3.1	5.14	-2.7	5.43	-7.9
4.57	+9.4	4.86	+2.9	5.15	-2.9	5.44	-8.1
4.58	+9.2	4.87	+2.7	5.16	-3.1	5.45	-8.3
4.59	+8.9	4.88	+2.5	5.17	-3.3	5.46	-8.4
4.60	+8.7	4.89	+2.3	5.18	-3.5	5.47	-8.6
4.61	+8.5	4.90	+2.0	5.19	-3.7	5.48	-8.8
4.62	+8.2	4.91	+1.8	5.20	-3.9	5.49	-8.9
4.63	+8.2	4.92	+1.6	5.21	-4.0	5.50	-9.1
4.64	+7.8	4.93	+1.4	5.22	-4.2	5.51	-9.3
4.65	+7.5	4.94	+1.2	5.23	-4.4	5.52	-9.4
4.66	+7.3	4.95	+1.0	5.24	-4.6	5.53	-9.6
4.67	+7.1	4.96	+0.8	5.25	-4.8	5.54	-9.8
4.68	+6.8	4.97	+0.6	5.26	-5.0	5.55	-9.9
4.69	+6.6	4.98	+0.4	5.27	-5.1	5.56	-10.1
4.70	+6.4	4.99	+0.2	5.28	-5.3	5.57	-10.2
4.71	+6.2	5.00	±0.0	5.29	-5.5	5.58	-10.4
4.72	+5.9	5.01	-0.2	5.30	-5.7	5.59	-10.6
4.73	+5.7	5.02	-0.4	5.31	-5.8	5.60	-10.7
4.74	+5.5	5.03	-0.6	5.32	-6.0	5.61	-10.9
4.75	+5.3	5.04	-0.8	5.33	-6.2	5.62	-11.0
4.76	+5.0	5.05	-1.0	5.34	-6.4	5.63	-11.2
4.77	+4.8	5.06	-1.2	5.35	-6.5		
4.78	+4.6	5.07	-1.4	5.36	-6.7		

Figure 166—Percentage of Error Table—5 Cu. Ft. Proving Head, page 542.

standard, and the error of the meter, expressed by Method "R," is an exact indication of the adjustment to be made. If it were true that an appreciable per cent of proof tests made bill adjustments necessary, or even that of the comparatively few meters whose tests necessitate such adjustment, the percentage of error

FEET PASSED ACCORDING TO PROVER	PERCENT OF ERROR	FEET PASSED ACCORDING TO PROVER	PERCENT OF ERROR	FEET PASSED ACCORDING TO PROVER	PERCENT OF ERROR	FEET PASSED ACCORDING TO PROVER	PERCENT OF ERROR
9.00	+11.1	9.29	+7.6	9.58	+4.4	9.87	+1.3
9.01	+11.0	9.30	+7.5	9.59	+4.3	9.88	+1.2
9.02	+10.9	9.31	+7.4	9.60	+4.2	9.89	+1.1
9.03	+10.7	9.32	+7.3	9.61	+4.1	9.90	+1.0
9.04	+10.6	9.33	+7.2	9.62	+4.0	9.91	+0.9
9.05	+10.5	9.34	+7.1	9.63	+3.8	9.92	+0.8
9.06	+10.4	9.35	+7.0	9.64	+3.7	9.93	+0.7
9.07	+10.3	9.36	+6.8	9.65	+3.6	9.94	+0.6
9.08	+10.1	9.37	+6.7	9.66	+3.5	9.95	+0.5
9.09	+10.0	9.38	+6.6	9.67	+3.4	9.96	+0.4
9.10	+9.9	9.39	+6.5	9.68	+3.3	9.97	+0.3
9.11	+9.8	9.40	+6.4	9.69	+3.2	9.98	+0.2
9.12	+9.7	9.41	+6.3	9.70	+3.1	9.99	+0.1
9.13	+9.5	9.42	+6.2	9.71	+3.0	10.00	±0.0
9.14	+9.4	9.43	+6.0	9.72	+2.9	10.01	-0.1
9.15	+9.3	9.44	+5.9	9.73	+2.8	10.02	-0.2
9.16	+9.2	9.45	+5.8	9.74	+2.7	10.03	-0.3
9.17	+9.1	9.46	+5.7	9.75	+2.6	10.04	-0.4
9.18	+8.9	9.47	+5.6	9.76	+2.5	10.05	-0.5
9.19	+8.8	9.48	+5.5	9.77	+2.4	10.06	-0.6
9.20	+8.7	9.49	+5.4	9.78	+2.3	10.07	-0.7
9.21	+8.6	9.50	+5.3	9.79	+2.2	10.08	-0.8
9.22	+8.5	9.51	+5.2	9.80	+2.0	10.09	-0.9
9.23	+8.3	9.52	+5.0	9.81	+1.9	10.10	-1.0
9.24	+8.2	9.53	+4.9	9.82	+1.8	10.11	-1.1
9.25	+8.1	9.54	+4.8	9.83	+1.7	10.12	-1.2
9.26	+8.0	9.55	+4.7	9.84	+1.6	10.13	-1.3
9.27	+7.9	9.56	+4.6	9.85	+1.5	10.14	-1 4
9.28	+7.8	9.57	+4.5	9.86	+1.4	10.15	-1.5

Figure 167—Percentage of Error Table—10 Cu. Ft. Proving Head, page 542.

was large, there might be a valid argument for *incorrectly* representing the percentage of error of all tests, and, therefore, of the meter condition, by using Method "R," in order that in some cases the result could be used for bill-correcting purposes. A meter is, however, so nearly perfect as a measuring instrument

FEET PASSED ACCORDING TO PROVER	PERCENT OF ERROR	FEET PASSED ACCORDING TO PROVER	PERCENT OF ERROR	FEET PASSED ACCORDING TO PROVER	PERCENT OF ERROR	FEET PASSED ACCORDING TO PROVER	PERCENT OF ERROR
10.16	-1.6	10.45	-4.3	10.74	-6.9	11.03	-9.3
10.17	-1.7	10.46	-4.4	10.75	-7.0	11.04	-9.4
10.18	-1.8	10.47	-4.5	10.76	-7.1	11.05	-9.5
10.19	-1.9	10.48	-4.6	10.77	-7.2	11.06	-9.6
10.20	-2.0	10.49	-4.7	10.78	-7.2	11.07	-9.7
10.21	-2.1	10.50	-4.8	10.79	-7.3	11.08	-9.8
10.22	-2.2	10.51	-4.9	10.80	-7.4	11.09	-9.8
10.23	-2.3	10.52	-4.9	10.81	-7.5	11.10	-9.9
10.24	-2.3	10.53	-5.0	10.82	-7.6	11.11	-10.0
10.25	-2.4	10.54	-5.1	10.83	-7.7	11.12	-10.1
10.26	-2.5	10.55	-5.2	10.84	-7.8	11.13	-10.2
10.27	-2.6	10.56	-5.3	10.85	-7.8	11.14	-10.2
10.28	-2.7	10.57	-5.4	10.86	-7.9	11.15	-10.3
10.29	-2.8	10.58	-5.5	10.87	-8.0	11.16	-10.4
10.30	-2.9	10.59	-5.6	10.88	-8.1	11.17	-10.5
10.31	-3.0	10.60	-5.7	10.89	-8.2	11.18	-10.6
10.32	-3.1	10.61	-5.8	10.90	-8.3	11.19	-10.6
10.33	-3.2	10.62	-5.8	10.91	-8.3	11.20	-10.7
10.34	-3.3	10.63	-5.9	10.92	-8.4	11.21	-10.8
10.35	-3.4	10.64	-6.0	10.93	-8.5	11.22	-10.9
10.36	-3.5	10.65	-6.1	10.94	-8.6	11.23	-11.0
10.37	-3.6	10.66	-6.2	10.95	-8.7	11.24	-11.0
10.38	-3.7	10.67	-6.3	10.96	-8.8	11.25	-11.1
10.39	-3.8	10.68	-6.4	10.97	-8.8		
10.40	-3.9	10.69	-6.5	10.98	-8.9		
10.41	-3.9	10.70	-6.5	10.99	-9.0		
10.42	-4.0	10.71	-6.6	11.00	-9.1		
10.43	-4.1	10.72	-6.7	11.01	-9.2		
10.44	-4.2	10.73	-6.8	11.02	-9.3		

Figure 167 (continued)—Percentage of Error Table—10 Cu. Ft. Proving Head, page 542.

that even where there are hundreds of thousands in use, those yearly found 5 per cent or more fast can be counted by hundreds only. Therefore, the practice of expressing the test result by Method "D," and of rebating bills on these results, while it gives the consumer a larger allowance than is actually due him, involves, even in a large situation, only negligible overpayments, and if the accounting office desires to be exact in all adjustments, the few additional calculations require little time. In applying Method "D," the "Percentage of Error" tables, Figures 165, 166 and 167 are utilized.

To show concretely how Method "R" does not express correctly the meter condition, and how great may be its error under extreme conditions, the example below is given:

Meter Reading = 2.00 ft. Prover Reading = 1.00 ft.

$$\text{Method R: } \frac{(2.00-1.00)\times 100}{2.00} = 50 \text{ per cent fast.}$$

$$\text{Method D: } \frac{(2.00-1.00)\times 100}{1.00} = 100 \text{ per cent fast.}$$

The latter answer is manifestly correct, because the meter has registered just twice the actual volume passing through it.

Never take for granted that a certain size meter contains a proving head with a certain number of feet, but make sure of the size of the proving head, and obtain the error from the proper column of the table.

Disposal of Meter

It has been stated that the proof test furnishes evidence of a meter's condition valuable in determining the subsequent procedure in the repair shop. A meter is said to *pass* the check test when the registration is correct, or the percentage of slow or fast error does not exceed the limits allowed by the company or prescribed by law. Most of the state commissions allow 2 per cent either way. Prior to the advent of such legal regulation, good company practice was to consider any meter correct between the limits of 2 per cent slow and $1\frac{1}{2}$ per cent fast. The fact that the error of registration is within allowable limits does not necessarily mean that no further work is advisable. This is apparent from the diagrams of test procedure given later. The exact sequence of tests following the check test will vary according to local conditions; for instance, whether a company does all its own meter repairing, and if so, at one or more locations, or whether meters

requiring more than minor repairs are shipped to another town. These subjects will be discussed to a greater extent later on.

If the meter does not pass the check test, but its error is within certain limits varying somewhat with different companies, the top is removed and the error corrected by shifting the position of the tangent post along the tangent arm. This is called "adjusting" and is more fully explained on page 549.

If the proving head pointer does not move during the check test, the meter no longer registers and is called a "Cease to Record." If the meter does not permit any air to pass through it, it no longer functions and is a "Won't Pass Gas."

Burner Test

On page 514 it was stated that one of the reasons for the removal of meters was a "partial failure to register the gas consumed." Therefore, each meter brought in for especial examination, or whose previous tests indicated the necessity for repairs that would alter its existing working conditions, is given a "burner test" to determine its ability to record at a consumption rate of about six cubic feet per hour.

The burner test is given to those meters removed from service which test over 10 per cent slow on the check test, in order to ascertain if the meters will show a movement of the test hand when passing gas at the comparatively slow rate required to supply one 6-foot burner. The test is based on the assumption that if a meter is over 10 per cent slow on the check test, it probably contains internal leaks which permit more or less gas to pass without registering. This test is made for the purpose of imparting additional useful information to aid in adjusting charges with consumers in cases of very slow meters.

The burner bar, A, Figure 168, should be composed of separate sections, upon which are mounted three 7-foot Bray burners, used chiefly for purging purposes, and controlled by one cock; one 6-foot Rappleye burner, for use in the burner test proper, and one half-foot Rappleye burner, for the slow motion test. A piece of safety gauze is inserted in the piping at each section, to prevent flame travelling back and causing an explosion in the meter.

The test routine follows:

> Connect meter to burner bar, and, unless filled with gas, purge it by turning on and lighting the three purging burners for the time given in Column D of

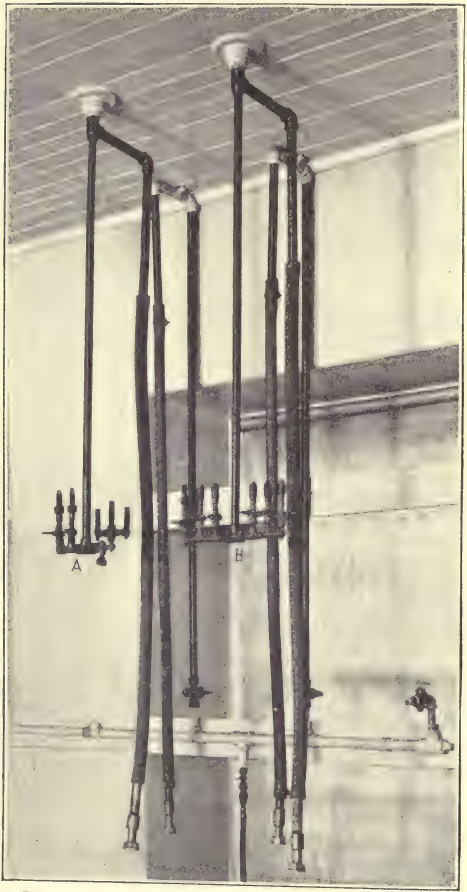


Figure 168—A. Burner Bar, page 543. B. Works Catch Bar, page 556.

the table, Figure 169, which, at their burning rate, should cause one complete revolution of the tangent arm. Then turn off the burners, and after marking the position of the proving head pointer by a dot of ink on the index glass, light the 6-foot burner and observe whether the required movement of the proving head pointer occurs in the time given in Column E, which involves at least one revolution of the tangent arm. If so, the meter has passed the test. As the test is, essentially, the verification of a given movement in a given time, accurate observation is essential.

A	B	C	D	E	F	
Size of		Revolutions of Pointer	Time for			
Meter	Proving Head		Purging	Burner Test	Slow Motion Test	
lt. "A"	cu. ft.		min.	min.	hr.	min.
3	2	1/16	½	1½	—	19
5 or 5	2	1/12	½	2	—	25
10 " 10	5	1/18	1	3	—	42
20	5	1/10	1½	5	1	15
	10	1/20	—	5	1	15
30 " 30	5	1/6	2½	8	2	5
	10	1/12	—	8	2	5
45	10	1/8	3½	14	3	28
	20	1/16	—	14	3	28
60 " 60	10	1/5	6	20	5	0
	20	1/9	—	22	5	34
100	20	1/6	10	33	8	20

Figure 169. Burner and Slow Motion Test Table, page 543.

If the pointer does not move the required distance in the given time, but shows *some* movement, the test should be repeated, unless there has been a previous slow motion test. Before making this second test, all marks of the first should be erased. If on the second try the conditions are fulfilled, the test is considered passed.

A device of flat brass, known as a proving head gauge, Figure 170, is of service in observing the fractional movement of the

pointer in any meter whose proving head is not divided to show the movement corresponding to a revolution of the tangent arm. In using it, the small hole is made central with the proving head spindle and one leg of the notched out division placed in line with the original position of the pointer as marked by the dot of ink. In this way, any motion may be conveniently measured.

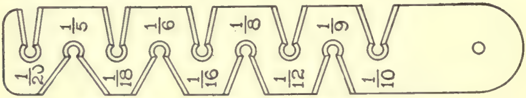


Figure 170—Proving Head Gauge, page 545.

The purging and test table should be posted under the burner bar for convenience of use. A clock showing seconds should also be in position for easy reading.

When starting the test, the time it is to be stopped should be chalked either on the inside of the index box lid or on the gallery plate.

If the top is off the meter, a piece of tin bent at a right angle should be set, at the start of the test, back of and touching the tangent arm, so as to be knocked down by the latter on the completion of a revolution. This furnishes an easy method of knowing whether the required movement took place within the time allowed.

There does not seem any justification for the practice that is sometimes followed when there is no movement with one burner, of lighting burner after burner until motion occurs, with the idea that the exact rate at which recording begins will be of service in rendering an estimated bill, for in the total absence of reliable knowledge as to the rates at which the meter formerly worked, the company's best guide is the consumption in previous years, and the only information it needs from the burner test is that the meter does not record under small consumption, and that to this may be justly ascribed any previous extremely low registration while in service.

Slow Motion (or Small Flame) Test

The "slow motion test" is of great importance in determining whether a meter is in proper condition to be put again into service. It should be given to all meters removed from service which have fallen within the "adjustment limits" on their first check test. It determines delicately whether or not there are

any minute internal leaks which permit gas to pass without registering. It may be queried, if the meter tests "correct" on the check test, why is any slow motion test needed? The answer is, that in adjusting the meter, the stroke of the diaphragms may be altered so as to counteract and obscure the effect of a small constant leakage at the uniform rate of speed of the check test. A meter so adjusted would show correct on the check test, whereas if the internal leak were stopped, the meter would at once show fast. If the slow motion test is made first, all internal leaks are insured against, and the final adjustment is known to be correct. Meters failing to pass the slow motion test should go to the repair shop.

All meters that are being fitted up after undergoing repairs should receive the slow motion test. No meter should go into O. K. stock which fails to pass this test.

The slow motion test differs from the burner test only in the rate of gas flow, the one burner used being adjusted to one-half a cubic foot per hour. All the directions and precautions given for the burner test apply equally to the slow motion test, but there is still more reason for care in marking the starting and stopping position of the proving head pointer. Also, it is recommended that the man who starts the test, completes it. That this would not necessarily follow is plain from the time required for the test as given in Column F, Figure 169. It is evident that this is a very delicate test, and that if leaks exist at diaphragms or valves, they will become apparent by providing a passage for this small amount of gas passing through, without causing any, or, at least, adequate, motion of the diaphragms and, therefore, of the tangent arm.

It will be noted throughout that in all tests made with the meter top off, the unit of movement is one revolution of the tangent arm. This is so, because such a movement corresponds to one complete cycle of operations within the meter.

Open Test

The open test is not made as a part of the process of fitting again for service those meters which, on their first check test after removal, came within the adjustment limits. This test is confined to meters undergoing repairs, and is thus a repair shop test. It is given to every meter removed from service on which work has been done that might change the position of the valves with relation to the diaphragms. Its purpose is to insure

that the valves are properly set with reference to the diaphragm stroke, so that the meter, if adjusted to register correctly at one rate of flow, will register correctly at any or all other rates of flow. The test consists in making a trial of the accuracy of registration at two widely different rates of flow. A very slow and a very fast rate would be the most positive test, but as very slow rates consume considerable time, the practice is to make the test at the rate of flow of the check test (known as the "check run") and at the rate of flow of a wide open outlet (known as the "open run") and to assume that if the valves are so set as to register the same at these two rates, they will so register at all other rates. The connections with the meter prover should be sufficiently large to insure a rate of flow on the open run at least double that on the check run. On some of the larger meters it may be necessary to make the check run at a slower rate, by using a cap with a smaller hole in the diaphragm than the standard check test hole. The process by which the mechanism is changed to accomplish a correct registration at all rates of flow, is known as "setting the valves."

The preliminaries for this test are in every way similar to those described for the check test. In addition, the short flag arms are lifted off the tangent post, and the tangent revolved by hand a sufficient number of times for the crank spiral to engage each tooth of the horizontal axle wheel, in order to detect any binding that may exist. Flag rods are next tried for bind in stuffing boxes and to determine the amount of lift. The flag arms are then replaced on the tangent post if the previous examinations showed satisfactory conditions, care being taken to oil the flag arm bearings with No. 4 Neutral oil, or other good light lubricating oil, and to note that the ends of the short flag arms rest flat on each other and on the shoulder of the tangent post. If there is any bind in the stuffing boxes, it should be remedied before proceeding with the test.

Then, with the outlet wide open, the prover is started at zero on the scale, and a complete revolution of the proving head pointer made. For convenience in calculating, the proof is stated as so many hundredths of a cubic foot passed by the prover while the meter is registering one cubic foot; as, for example, if the prover reading was 1.92 cubic feet and that of the meter was 2 cubic feet, the proof, reduced to terms of 1 cubic foot, would be stated as $192 \div 2 = 96$. This open run is preceded by a check run, the result of which is expressed in the same way.

If the check and open runs differ from each other by more than 0.5, the process known as "setting the valves" is required. This is followed by the process of "adjusting," in order to bring the proof to within 0.5 of 100.

During the runs required by the "setting the valves" process, advantage is taken of the opportunity of checking the correctness of the index. In describing the measurement of gas flow, it was said that the number of teeth on the horizontal axle wheel, together with the displacement capacity of the measurement chambers, determined the volume measured during one revolution of the horizontal axle, and, therefore, the volume corresponding to a revolution of the proving head pointer; also, that this volume increased with the size of the meter and varied from two cubic feet to one hundred. Now, if in a meter whose horizontal axle made one revolution every two feet, was placed an index provided with a 5-foot proving head, it is clear that the meter would register two and a half times the volume actually passing through it. While the installation of the wrong index is of very rare occurrence, its detection is extremely desirable and is absolutely certain, if, during one of the runs, the workman is careful to note that the reading of the prover scale equals, approximately, the number of feet called for by the lettering on the proving head for one revolution.

Adjusting

"Adjusting" is the process by which those meters removed from service which came within the "adjustment limits" on their first check test, and which have afterward successfully passed the pressure and slow motion tests, are again made to register correctly. It consists in altering the length of stroke of the diaphragms so that the volume displaced by each stroke will correspond to the volume registered by the index gearing. Originally, it was so set, but in the course of service, due to wear and what not, the meter mechanism has gotten out of adjustment. In meters of the class now under consideration, it is assumed that nothing has happened to throw the valves out of their original condition of harmony with the strokes of the diaphragms, and that, therefore, if the strokes of the diaphragms are adjusted to register correctly at the rate of flow of the check test, they will also register correctly at all other rates. Consequently, the process of adjusting consists in moving the tangent post along the tangent arm (thus altering the length of the diaphragm stroke) and then making a check test; then moving the tangent post

again and testing again, repeating these processes alternately until the meter registers correctly on the final check test, at which time the tangent post is clamped in position.

After any motion of the tangent post, its final position should be such that its vertical axis should be perpendicular to the plane of revolution of the tangent arm. Though the exact extent to which the tangent post has to be shifted along the tangent arm in order to obtain any certain percentage of change, varies with the different types and sizes of meters, and can only be found out by experience in working with the different meters, the following table will serve as a valuable guide:

PERCENTAGE OF CHANGE IN PROOF
PER TURN OF JAM NUTS AND TANGENT POSTS

Size of Meter	Make	*Style of Tangents	Per Cent Per Turn
3-lt.	Other than Griffin	A	4 to 5
3-lt.	Griffin	B	2
5-lt.	Other than Griffin	A	4 to 5
5-lt.	Griffin	B	2
5-A	All	A	4
10-lt.	Other than Griffin and American	A	4
10-lt.	Griffin	B	1¼
10-lt.	American	A	3 and 4
10-A	All	A	4
20-lt.	Other than Griffin	A	4
20-lt.	Griffin	B	1¼
30-lt.	Other than Griffin	A	4
30-lt.	Griffin	B	1½
30-A	All	A	3
45-lt.	Other than Griffin	A	4
45-lt.	Griffin	B	1¼
60-lt.	Other than Griffin	A	2 and 3
60-lt.	Griffin	B	1¼
60-A	All	A	3
100-lt.	Other than Griffin	A	2
100-lt.	Griffin	B	½ and 1¼

* "A" in this column refers to that type of tangent where the position of the post is adjusted by turning the jam nuts, the post remaining in vertical position during the operation. A fraction of a turn of the jam nuts on these tangents will change proof a proportionate percentage of a whole turn.

"B" in this column refers to that type of tangent that has a jam nut which screws on the post and a post nut that must be turned around the arm to change the diameter of the circle through which the arm moves. A fraction of a turn of these posts cannot be made in adjusting meters.

This "adjusting" is a process that should be done in the meter testing shop of every gas company, as this practice saves the expense of sending many meters to a repair shop.

Setting the Valves

"Setting the valves" is a process requiring greater skill and experience than the process of adjusting. As already explained, it is required only on those meters in which some repair has thrown the strokes of the valves and of the diaphragms out of harmony. It involves the altering of the position, or angle, in which the tangent arm is attached (usually soldered) to the top of the crank. Similarly to the adjusting, it is a process of trial and error; first, a tentative setting of the arm, then an open test (open and check runs), and so on alternately until a position of the arm is reached in which the same registration is obtained at the rate of flow of the check run as at the rate of the open run. When this condition is reached, the tangent arm is soldered fast. The meter is afterward "adjusted" to register correctly on the check test.

The shift of the tangent arm is effected by wedging the crank and melting the solder joint by which the tangent arm is attached to the crank top, or in some modern types, where there is no solder joint, by screw adjustment. Any shift changes the open proof about twice as much as the check proof. If the meter proves less on the open than on the check run, to correct it, the tangent arm should be shifted in the direction in which it travels: and if the open proof is greater than the check proof, the tangent should be shifted against its travel.

If the open proof is less than the check proof, the difference between the two, added to the check proof, or twice the difference added to the open proof, will be the proof to be expected after the two runs have been equalized by a proper shift of the tangent arm. For example:

96 open		100 check
8		4
104	equalized proof	104

As this represents 104 hundredths of a cubic foot passed by the prover while the meter is registering 1 cubic foot, this meter will be slow when the two runs are equalized.

If the open proof is greater than the check proof, the difference between the two subtracted from the check proof, or twice the

difference subtracted from the open proof, will give the equalized proof, as in the example below:

100 open	96 check
8	4
92 equalized proof	92

From what has gone before, it is evident that this meter will be fast when the proof is equalized.

After shifting the tangent arm in accordance with the above directions, an open run is made. If this does not show the equalized proof indicated by the previous calculation, another shift is given to the tangent arm and the process of shift and open run continues until, on open run, the equalized proof is obtained. Then a check run is made, and this will always agree with the open run, except in the rare event of there being an inside leak which has escaped the slow motion test. Such a meter would be set aside for repair.

When the routine as just described results in the equalized proof on both open and check runs, if this proof is not equal to 100, it must be made so by altering the position of the tangent post along the tangent arm; i. e., by adjusting the meter. As the stroke of the diaphragms, and, therefore, the volume passed by the meter for the same registration of the proving hand, increases with the distance of the tangent post from the crank, measured on the tangent arm, it is clear that when the equalized proof is greater than 100, as in the first example, to *decrease* this proof, which means to *decrease* the volume passed by the meter for the same movement of the test hand, the tangent post should be moved *in* on the tangent arm. Conversely, to raise to 100 the proof of the second example, the tangent post must be moved *out*.

Having moved the tangent post as thought necessary, an open run is made, and the process of move and test is continued until the open run is within 0.5 of 100. Adjusting is ordinarily done by using the check test, but in this process of setting the valves, the repair shop workman, having just satisfied himself that the meter proves the same on the open and check runs, usually avails himself of the greater speed of the open run in adjusting the meter to 100. Having brought it so on the open run, he makes a check run, and if the proof of the meter on the latter is within 0.5 of its proof on the open run, and also within 0.5 of 100, the meter is accepted as having its valves properly set, and as being

in correct adjustment, and the flag arms wired to the tangent post. If the check run falls outside of the permitted limits, a new calculation is made, based on the last check and open runs, another shift given to the tangent arm, and the adjusting operation repeated.

An experienced workman does not follow exactly the routine above described; he takes short cuts. After shifting the tangent arm on the crank as much as he thought necessary, he would then move the tangent post along the arm in order to bring the equalized proof to 100; all this before making the first open run. The information available as to the proper change of the post is so accurate that it always may be safely assumed that any error resulting in the open run made after such procedure, is due to the adjustment of the arm on the crank.

It sometimes will happen that after an equalized proof has been obtained, the meter operates with a jerky motion. This indicates either that the flag arms are out of division, or the valves are not properly connected so as to move symmetrically on their seats, or perhaps both of these faults exist. With such a condition, the testing stops and the meter is examined as described under "Fitting Up." Any necessary adjustment of the flag arms would be made at once, but if the valves needed re-connecting, the meter would be returned to the fitter up.

Pressure Test

The previous tests have been to check the accuracy of the measuring mechanism. The pressure test is to determine the existence of any leaks in the case or table of the meter. It should be given to all meters removed from service that have come within the "adjustment limits" on their first check test. It is given also to all meters undergoing repairs as it is part of the process of fitting the meters again for service. It insures that there are no leaks from the meter case or columns into the atmosphere, or if the top is off the meter, through the table from below to above. It usually should precede the slow motion test.

The pressure commonly used is 9 inches of water column. When working with air, this pressure is conveniently obtained from a compressor (beer pump) operated by the pressure in the water mains. The compressor delivers into a 30-gallon boiler, which feeds through a small holder weighted to throw 9 inches pressure, or through a pressure governor. There is a cock between the boiler and the holder, and another on the outlet of the latter.

A hose connection leads from this to the meter, and there is an arch pressure gauge in this line.

If the meter top only has been removed, the test for the tightness of its replacing is made as follows: A small hole is punched in the top. Into this is inserted the conical end of a tin tube fastened to the hose connection, putty being used to make a tight joint. Both columns of the meter are left open. The outlet cock from the holder is opened, and closed when the pressure ceases to rise. Any subsequent loss of pressure indicates a leak, which is located with soapsuds, as described later on.

To test the columns and the body of the meter below the gallery, the pressure line is connected to the inlet column and a pet cock screwed on the meter outlet. This cock is opened and also the outlet cock from the holder, and air allowed to enter the meter through a $\frac{1}{8}$-inch hole in a tin disc placed in the pressure line. After the proving head pointer has made one-fourth of a revolution, showing that there is a clear passage through the meter, first the pet cock and then the holder outlet cock is closed. If the pressure as shown by the arch gauge drops, the outlet cock is again turned on and the leak search begun.

Any congealed condensation should be carefully scraped from the meter and the spot investigated with a sharp-pointed tool for a possible hole. If the top is off, first search for the leak in the case itself. After repairing any leak thus found, if a leak still exists, test around the caps of the stuffing boxes. The suds for this purpose should be of a soap such as "Ivory" or Fairbanks' "Fairy," that will not injure the wool packing. Wipe off carefully after testing. Any leaks found at stuffing boxes should be repaired temporarily with soft putty.

In its use of gas for meter testing, Philadelphia has found the pressure raising device, or "inspirator," shown in Figure 171, an inexpensive and effective instrument. As the illustration shows, it is designed on the principle of the steam injector. A jet of water $\frac{3}{32}$-inch in diameter, at main pressure, located in the run of the "suction tee," is directed through a nipple of $\frac{1}{8}$-inch pipe, and entrains gas entering through the side outlet of the suction tee. A proper water seal is provided, and the gas pressure is controlled by a governor. The extent to which this pressure may be raised will be proportional to the water pressure available. At 15 pounds water pressure, 16 cubic feet of gas per hour can be raised to 46 inches. No storage tank is required, for the

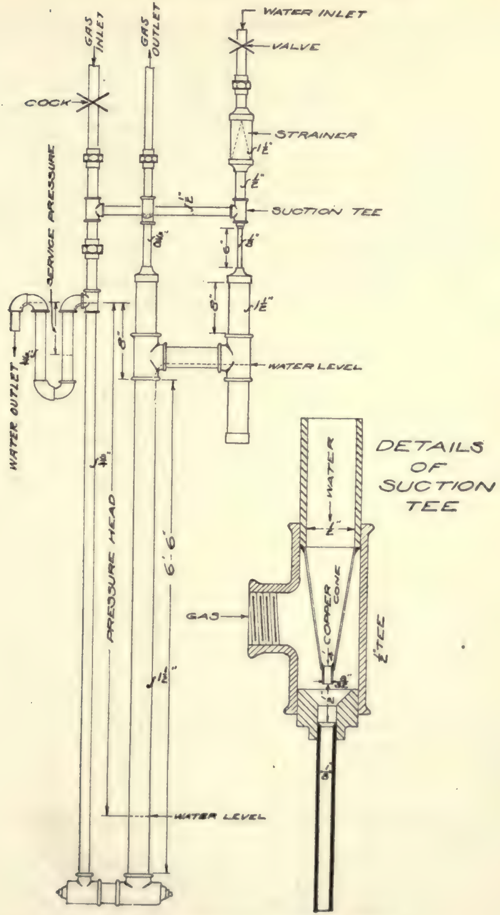


Figure 171—Inspirator, page 554.

pressure is quickly raised as soon as the water is turned on, and the flow is kept up until the completion of the test.

Works Catch Test

Any meter removed for "works catch," or which, on check test, is thought to bind and is not over 10 per cent in error, is tested for this binding or "catching" immediately following the check test. The meter is connected to a "works catch" bar, B, Figure 168, provided with one 6-ft. burner and five open-flame Jumbo burners, each of the latter consuming about 15 cubic feet per hour, and their flames are watched for any fluctuation during at least one revolution of the tangent. If no fluctuations are observed, the test is repeated, using the 6-ft. burner only. If on either test there is a fluctuation, the meter is set aside for opening and repair.

Prepayment Meter Tests

Open Cut-off Valve

There are three repair shop operations peculiar to prepayment meters that will be mentioned at this point. The first is the necessity of increasing the opening of the cut-off valve if its existing opening will not pass sufficient gas to make the check test. This should be done by the use of a dummy coin, unless for any reason the coin cannot be inserted in the slot part (2, Figure 127, page 448), or if the meter was removed for a special test "money wrong," which means there is some evidence that the valve is not opened to the proper extent for each coin deposited. In the first case, the slot part should be removed, and then the price wheel (2, Figure 128) is turned with the fingers until the credit dial pointer shows a credit of 25 cents, after which the slot part is replaced. In the second case, it is important that the buying mechanism be left undisturbed at this time, and, therefore, first, the slot part is removed, care being taken to see that the 50-tooth wheel (3, Figure 127) is not turned. Then the price wheel is turned with the fingers, as above described.

Test Buying Mechanism

The directions that follow apply to the mechanism shown in Figures 127 to 129.

Turn the handle all the way back and shake it to be sure no coin is left in the slot part. If the position of the credit dial pointer is such that 75 cents' worth can be bought without sending the pointer beyond the "Stop" line, buy three times

with a dummy coin, each time watching the credit dial. If the pointer moves the proper distance as measured with the credit dial gauge, the mechanism is O. K. If the credit dial shows that 75 cents' worth cannot be bought without the pointer going beyond the "Stop" line, remove the slot part and, by turning the price wheel with the fingers, run the gearing back until this condition is remedied.

If the insertion of a coin is prevented by an obstruction in the slot part, take off the latter and turn 50-tooth wheel to see whether slot will clear. If not, it will be necessary to remove brass plate on back of slot part, thus enabling access to interior. After replacing plate, adjust coin carrier if necessary, by moving 50-tooth wheel, to enable coin to drop in slot. Then, holding slot part in hand, insert coin and turn handle twice in succession, to insure that coin carrier is in alignment with slot. Before replacing slot part, examine gears for defective teeth. After part is replaced, make buying test already described.

Close Cut-off Valve

Remove the slot part, and with the fingers turn the price wheel back very carefully until you feel the valve seat. Then turn in the opposite direction for two teeth, to prevent undue strain on the valve-closing mechanism. Never blow into a meter to test for tightness of cut-off valve.

Fitting Up

"Fitting up" is the technical term used to describe the establishment of the correct position of the valves relative to their valve seats and to the diaphragms, as shown in Figures 123 to 126, pages 444 to 447. The first step is to attach the valve by the valve arm to the throw of the crank; revolve the crank by hand, and see whether the opening of the diaphragm port when the valve is at the end of the forward stroke, equals the opening of the case port at the end of the backward stroke. If not—and this is rarely the case with meters undergoing repairs—the valve wrist is shifted on the valve wire until the desired conditions are secured. The required 90° angular distance apart of the valves in the revolution of the crank, is obtained by the position of the valve seats and guides, which makes the two lines of travel at right angles to each other.

After both valves have been correctly connected with reference to their valve seats, the next step is to see whether the

relations of the flag arms with the flag rod and the tangent arm are such as to give the necessary simultaneous condition of diaphragms and diaphragm chambers shown on page 433. One of these is when the back diaphragm is filled, i. e., fully extended, and the back valve at midstroke (see Figure 124). When the valve is in this position, the tangent arm should point toward the back of the meter at a very slight angle toward the outlet side. The experienced workman is able to judge before moving the valve whether or not the tangent arm will come to the right position. If not, he places the valves at midstroke, wedges the crank fast and shifts the tangent arm on the crank as may be necessary.

To extend fully the back diaphragm, the workman moves the back long flag arm as far as it will go freely. In that position the long flag arm will be about parallel to the back gallery plate, and it should be possible to line up the short flag arm with the tangent arm as already placed. The free end of the short flag arm should not reach as far as the tangent post, because it must be remembered the short flag arm is in the position it would assume with the diaphragm fully extended, and, therefore, it should be *beyond* any position it can take when its free end is over the tangent post. Expressed in another way, it always should be possible after the tangent arm, with the flag arms in position, has been revolved to the point where one diaphragm has reached the limit of its outward stroke, to lift the corresponding short flag arm off of the post and move it out along the line of the tangent arm, before the diaphragm reaches full extension. This possibility of diaphragm travel, in addition to that occurring when the flag arm is on the tangent post, is necessary to prevent any strain on the flag rod and to allow for any future adjusting of the tangent post.

The condition of the back diaphragm entirely empty and the back valve at midstroke (see Figure 126) is tested by moving the tangent arm through half a revolution. Again the short flag arm should line up with the tangent arm, but this time the latter is pointing *away* from the short flag arm, and, therefore, when the diaphragm is entirely empty, the free end of the flag arm should extend *beyond* the tangent post, to insure the same leeway for the emptying stroke as that already described for the filling stroke. If the conditions as described for both these strokes are not fulfilled, the position of the long flag arm with relation to the flag rod must be changed by unmaking and then

re-making their solder joint attachment until the desired results are attained.

In a similar manner the correctness of the front flag arm, when the front diaphragm is in the positions shown in Figures 123 and 125, is established or secured. With the front diaphragm empty, the front long flag arm will be about parallel with the side of the meter. Then both sets of flag arms are attached to the tangent post. The correct positions of the tangent arm on the crank and of the post on the tangent arm are tested later, as described under "Setting the Valves" and "Adjusting," but in practice it is found that as a result of the fitting up operations, there is usually little or no correction required in these two particulars.

From the above, it will be seen that the fitter-up takes the meter after the diaphragms are in, and adjusts all of the moving parts so that they work properly together. His work in connecting the valves so that they move symmetrically on their seats is done with sufficient accuracy, so that after inspection, the valves are permanently closed in. On the other hand, as the fitter-up works without using a meter prover, his "setting of the valves" and his "adjustments" are necessarily only tentative, and are afterward tested out by the men who operate the meter provers, as already described.

Location of Work

Of the tests previously described, the check test has in some cases been made at consumers' houses. As a general practice, this is most unwise, for accuracy is almost impossible of attainment because of the difficulty of controlling temperature conditions. For those companies, however, having in use meters 500-lt. and larger, tests of these sizes in place will often result in acceptable economies by showing that the error of registration does not warrant removal. In such a test, a 10-A meter, well seasoned under the usual service conditions and checked frequently for accuracy, replaces the prover, and is connected to the outlet of the large meter by rubber hose. From its outlet, hose conveys the gas to a large appliance where it may be burned. The tightness of all valves and connections may be determined by a proper manipulation of the inlet and outlet valves of the large meter, and of a cock on the outlet of the test meter located beyond a U gauge. Before the test, both meters should be purged thoroughly.

The remaining tests and all the repairs are made either in a repair shop belonging to the company, or, especially where the

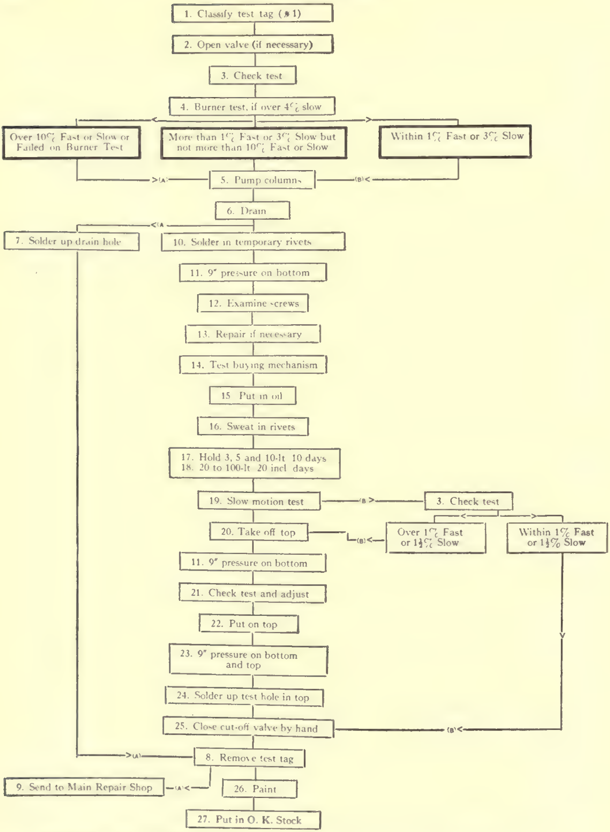


Figure 172. Tests of Non-Dipping Meters at District Shop.

NOTE.—In reading this table, the central vertical row of lines joining the tests or operations is not lettered. The two side rows are lettered *A* and *B* respectively, to show where they merge into or leave the main row. For example, processes 5 and 6 in the central row are made on the left-hand group of meters (*A*) and are followed by process 7.

company is a small one, for reasons of economy, adjusting and the minor repairs only may be made by the company, and meters requiring more extensive work sent to the repair shop of a large company or of a meter manufacturer. In Philadelphia, it has proved cheapest to do adjusting and to make minor repairs at

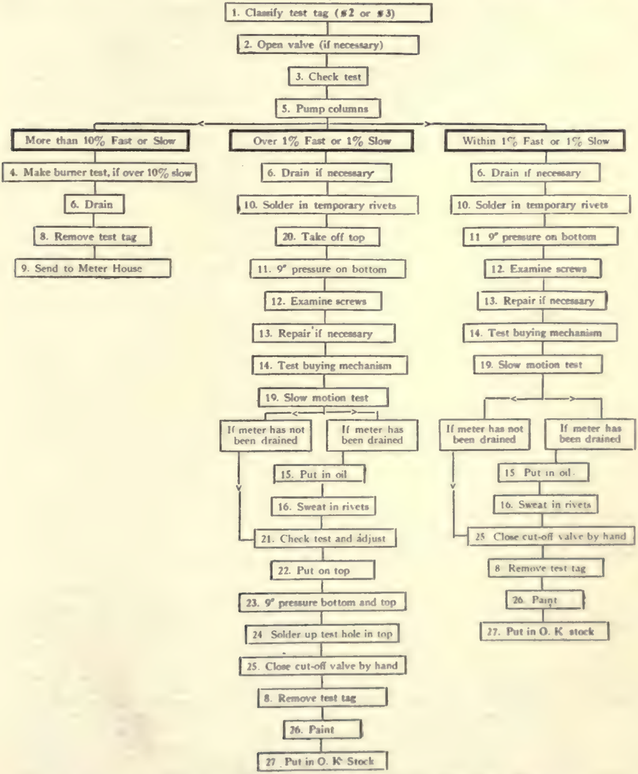
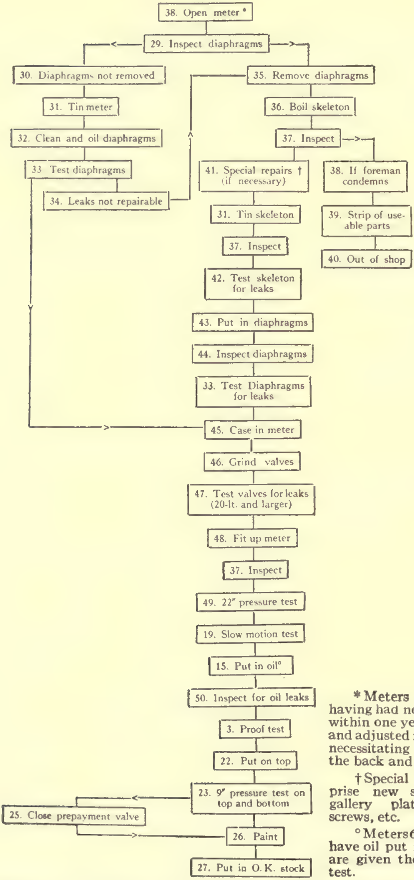


Figure 173. Test of Dipping Meters at District Shop.



* Meters purchased, or having had new diaphragms within one year, are cleaned and adjusted if not damaged necessitating the removal of the back and front.

† Special repairs comprise new sides, bottom, gallery plates, columns, screws, etc.

° Meters 60-lt. and larger have oil put in before they are given the slow motion test.

Figure 174. Tests of Meters at Main Repair Shop.

each of the district shops. This has enabled the placing back in service of two-thirds of all the meters removed, without undergoing the expense of their transfer to the central repair shop. The number of meters that can be satisfactorily cared for at each district shop has been appreciably increased by their practice of setting aside meters requiring certain repairs beyond the skill of the district employees. This work is done by a visiting repairer, who comes to each district shop from the main repair shop as occasion demands. This method is not available to companies whose repair shop is not in the same city.

The exact apportionment of testing and repairing as between two such repair locations will vary according to local conditions. In discussing the order of work as followed in Philadelphia, its apportionment will become apparent.

Order of Work

Figures 172, 173 and 174 show, in tree form, the order of operations,— the first two in the district shop, and the last in the main repair shop. The nondipping tests, Figure 172, have come to an end with the complete conversion of all the meters, but are included for the benefit of any company passing through a conversion period.

The order shown for the tests has proved to be the one now requiring the least handling of meters. In the future, as has often occurred in the past, the desirability of a special investigation or of a change in the existing policy of handling and testing may alter the present arrangement. To facilitate any revision, there is a separate instruction card calling for each operation. These are called "Order-of-Test Cards," and may be put in any sequence desired. Each operation is described in detail on typewritten sheets, and there is cross reference between the sheets and the cards.

For convenience of reference, numbers have been assigned to each operation shown in the trees, and some of these operations are commented on below under their numbers.

(1) At this point the meter is assigned to its proper class, 1, 2 or 3, for the information of the workmen introducing oil and riveting the oil holes.

(3) In Figure 174, "Proof Test" means either a check test leading to an adjustment, or a "setting the valves," depending on the nature of the repair that has been made to the meter.

(4) On nondipping meters, the burner test follows the check test, in order to determine most economically those meters which will not pass the test and which, therefore, must be sent to the main repair shop. Also, any meter which fails on any district shop test is at once given the burner test and sent to the main repair shop.

(14) This test is made immediately after the check test, on any meter for which it is necessary to open the valve, except a "money wrong."

(19) All meters failing to pass this test should be given the burner test and then sent to the repair shop. This test, on nondipping meters, *follows* putting in the oil, because it has been found that, after the oil has been in for the time required by (17) and (18), more than 50 per cent of the meters which would not pass the slow motion test without oil, are made O. K. by the fact that the oil has closed the pores of the leather.

(20) The instructions for this operation are as follows:

> Scrape off paint from seams and apply flux to exposed solder. Use soldering iron that does not show any heat color, as a very hot iron might cause an explosion by lighting vapors from the columns or partly opened seams. Tilt meter so that melted solder will not fall inside. Make sure that all solder is off before attempting to remove top, as hacking or prying off the top should never be done as this will spring the gallery plates out of shape.
>
> After the top is off, tin the top flanges, being careful to keep solder out of index gearing. Float solder around the base of the meter screw to make a tight joint between the base of the screw and the body of the meter. Be careful not to let solder run into column, nor to heat screw to such an extent as to injure the sweated joint between the screw and column. Straighten out any dents in top, tin the edges, and run solder out of test hole.

(22) The instructions for this operation are as follows:

> See that flag arms are connected to tangent post and pin or wire properly fastened in tangent post hole; also, that all exposed bearings and cups in stuffing box caps are well oiled. If gallery plate is sprung out of shape, straighten by holding a stout

wooden strip against top flange and tapping with mallet or hammer. If top flanges are bent, straighten with flat-nose pliers.

Hold top in position, and if necessary, tap it with a small hammer until it touches the flanges at every point. Then tack it on and put flux on parts to be soldered. Solder on tight, and be careful to prevent solder from dropping inside, especially when working above the index. For this reason, do not use too hot an iron, too much flux, nor tip the meter very far back. Put a fillet of solder at the base of the meter screw, following the same precautions as when removing top.

SECTION III

FORMS AND RECORDS

CHAPTER LI

SHOP RECORDS

Explanatory

The records that will be described briefly are those in use in Philadelphia, with its several district and one main repair shop. With perhaps minor variations to suit local conditions, they are applicable to any situation. The value of the card forms and of the record by meter number of location and of repair, has been demonstrated thoroughly. (Here and elsewhere throughout this Manual, all "card" forms, unless otherwise stated, are of Standard Library Bureau size, viz., approximately 3 by 5 inches. Also, though spoken of as cards, they are usually printed on paper thin enough to allow for carbon copies.)

Company Number

Every meter should have a company, as well as a maker's, number. The company number badges should be furnished in serial numbers to the meter maker for soldering to the front gallery plate before shipment. This location enables the badge to remain on the meter during all subsequent repairs, thus absolutely identifying that particular meter from the date of purchase. The use of the company number avoids any duplication of meter numbers in the records, as might happen if maker's numbers were used and meters bought from more than one maker. It also enables, for most companies, the use of numbers containing four or, at most, five digits, as against six or seven digits in the maker's numbers.

Shipping List

Meters shipped between different shops or testing stations are accompanied by a shipping list, showing date of shipment, company number, size and kind of each meter. In a shipment from the main repair shop to the district shop, the meter index is also shown. In preparing these lists and all other meter records, great care should be taken in writing and checking the company number and index reading. At the receiving point, the shipping list is checked with the accompanying meters, and any mistake is immediately taken up by letter with the shipping point. This insures the correctness of all records.

District Repair Shop

Meter Stock Card

In each district shop is kept, for each meter in the district stock, a meter stock card, showing the date the meter was received, the size, kind, number and index. These cards are originated as meters are received from service or from the main repair shop, and are cancelled when the meters are sent out of the district stock to the main repair shop, or to be placed in service; in the latter case, after the completed meter order cards have been returned. By this record the exact district meter stock may be quickly determined at any time, and a check had on the meter information shown on completed "Set" or "Change" cards. When meters are shipped from the district shop to the main repair shop, the shipping list, as made out from the meters, is checked with the stock cards.

From time to time, inventories are taken of the meters in district stock. Any failure to account for every meter shown by the shipping list or stock cards as received in the district, results in a search for the missing meter, the number of which is, of course, known. This search is greatly facilitated by the information shown on the location card for that particular meter.

Meter Test Sheet

The result of a check test of a meter in the district shop is entered in duplicate on a "Meter Test Sheet," and the original sheet sent to the main repair shop the following morning, in order to furnish the earliest possible information about the test of removed meters.

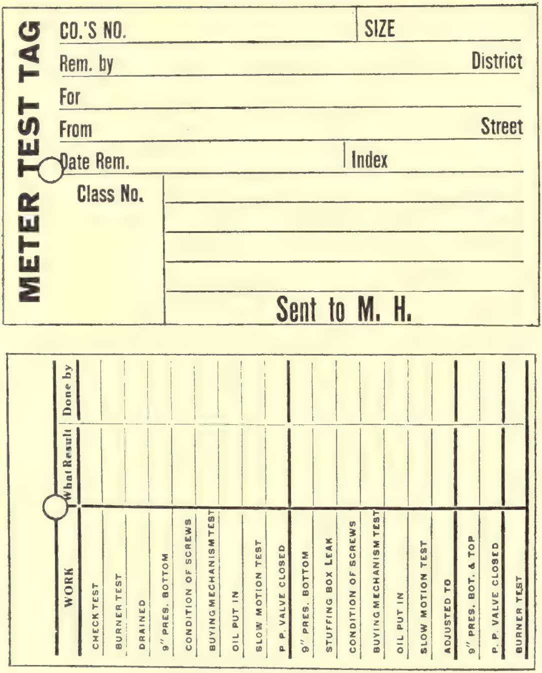


Figure 175.—Meter Test Tag, page 568.

METER TEST TAG

To every removed meter, a "Meter Test Tag," Figure 175, is attached. It provides a record for every district repair shop operation, and remains with the meter until all such work is complete, after which it is forwarded to the main repair shop. Here it is filed by company number for six years, for possible future reference, after the information opposite "Date Removed" and "Index" has been posted on the "Meter Location Card"

SIZE........	Co. No.	Maker,	
By Whom	Nature of Repair		Date
Repaired	Purchased:		

Figure 176.—Meter Repair Card, page 571.

and that referring to certain tests, in the "Meter Tests Book," as hereafter described.

Main Repair Shop

Meter Record Book—Repair Card—Location Card

As each new meter is received from the maker, the company number, size, kind, maker's name and number, and date of pur-

SIZE	KIND	Co. No.		MAKER		MAKER'S NO.	
SET					REMOVED		
DATE	INDEX		STREET	HOUSE NO.	DATE	INDEX	

Figure 177.—Meter Location Card, page 571.

TESTS OF METERS UPON REMOVAL

CLASS______ MONTH________ YEAR__________

CO'S. NO.	PER CENT ERROR											COR-RECT	WON'T PASS GAS	CEASE TO RECORD
	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	OVER 10%			

Figure 178.—Meter Tests Book, page 571.

chase is entered in a "Meter Record Book." This data is copied upon a "Meter Repair Card," Figure 176, which is filed numerically by the company number of the meter. Each subsequent repair or shipment is entered on the proper repair card.

A "Meter Location Card," Figure 177, containing the same information as the meter record book, is written up at the same time as the repair card. It also is filed by company number, and on it is entered the information called for each time the meter is set or removed. Both sides of the card are used.

When a meter is condemned, lost, sold, destroyed, or converted from an ordinary to a prepayment, the fact is entered in the three records just mentioned. (A meter after conversion is given a new company number and treated as a new meter.) It is readily seen that the complete history of any meter is immediately accessible. The "Meter Record Book" should be stored in a fireproof place, containing, as it does, the data for starting new card records in case the latter are destroyed or lost.

Meter Tests Book

The information required by the "Meter Tests Book," Figure 178, is obtained from the meter test tag. The exact check test results are entered in the appropriate columns. One book is used for slow errors only, and another book for fast errors and for "correct," "won't pass gass" and "cease to record" meters.

Monthly totals are obtained, and from these the yearly summary is prepared. This includes the average error of slow and of fast meters, and the average net error of all meters.

Miscellaneous Records

A chronological book record of company number only is kept of the meters set each day. This practice was started July 1, 1914. As Philadelphia is working under a five-year change rule, the record began to be of use in the spring of 1919. Then the numbers shown as set in July, 1914, were looked up on the corresponding meter location cards, and for each meter for which there was no subsequent record of removal, a "Change" card was written and these orders executed about July, 1919. In this way, month by month the periodic renewals will be made. Without this chronological record, it was necessary to look over all of the meter location cards and note down the numbers of meters that had been nearly five years in service.

Meters which for any reason are not removed on a "five-year change" order, are ordered out again at intervals of six months

until the change is effected, and in the meantime, a special record is kept of them to prevent any possibility of their being forgotten.

A list of locations from which rusted meters have been removed in each district after four years or less of service, is made out at the main repair shop each month and forwarded to the district superintendent for his attention.

Other records show meters owned, in use, condemned, causes of removal, reasons for sending meters to the main repair shop, cost of repairs, and any other useful information, including the results of experiments and investigations made from time to time. From these records, any marked change in practice or conditions at any shop is quickly seen, and any advisable alteration in the method of testing or handling meters may then be made.

CHAPTER LII

METER ORDER CARDS

The preceding chapter touched upon the care taken by the distribution department to preserve an individual history of each meter and a record of all meters in stock at any time. The principal reason for these records is the vital importance to a gas company of having easily available and accurate meter data. It is essential that the information on the Meter Location Card, Figure 177, be correct. Errors affecting company number or location may cause considerable annoyance and expense, and those involving registration may result in injustice to, and cause dissatisfaction on the part of, consumers. Again, if a meter is set and a record of the installation lost, there is a probability of considerable loss of revenue before the meter can be found.

For the above reasons, it is quite imperative that no meter work should be done except from a proper order card. This order card will be either a "Set," Figure 179, "Change," Figure 180, or "Remove" card, Figure 181, and should be serially numbered to enable the easy detection of the loss of a card, as explained on page 576.

Each card as issued by the commercial department should be in triplicate. The triplicate is held as a check to insure the return of the original order, which, with the duplicate, is sent to the distribution department. The original goes with the fitter, the duplicate being held in the shop until the completion of the work and the return of the original to the commercial department.

A "Set" card should be issued by the commercial department only. "Remove" and "Change" cards, however, frequently must be issued (originated) by the distribution department in order to give prompt service to the consumer. When a card is thus originated, it is issued in duplicate by the distribution department, which, on completion of the work, sends the

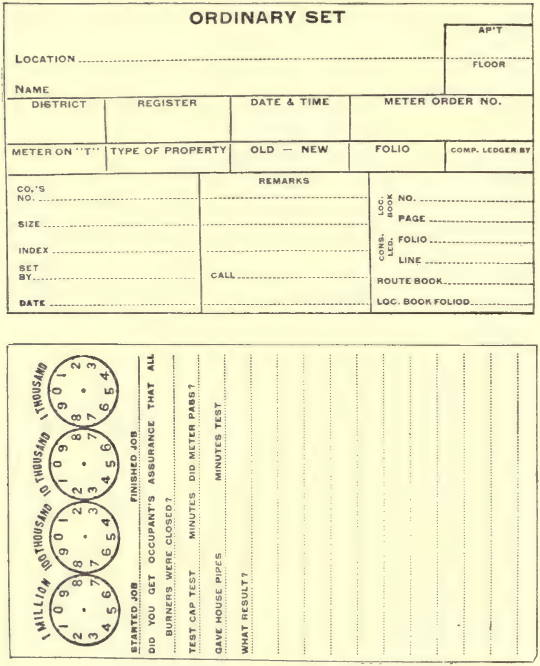


Figure 179.—Meter Set Card, page 573.

original to the commercial department, and at that time it is numbered. Experience has shown that the check afforded by the duplicate held in the shop, prevents the loss of originated orders, and, therefore, makes unnecessary any notice to the commercial department of an originated order other than the receipt by them of the unnumbered completed card.

For each meter sent out with a fitter, the meter number, size and kind is charged against him, as per the stock cards removed from file, on a sheet left in the shop. On executing the meter

ORDINARY CHANGE				
LOCATION				S R E / AP'T
NAME				FLOOR
DISTRICT	TYPE OF PROPERTY	DATE & TIME	METER ORDER No.	
REASON			FOLIO	COMP. LEDGER BY

METER SET	METER REMOVED	
CO'S NO.		LOC. BOOK NO
		LOC. BOOK PAGE
SIZE		CONS. LEG. FOLIO
INDEX		CONS. LEG. LINE
REMARKS	CALL	ROUTE BOOK
CHANGED BY	DATE	LOC. BOOK FOLIO

Figure 180.—Meter Change Card, page 573.

ORDINARY REMOVE				
LOCATION				S R E / AP'T
NAME				FLOOR
DISTRICT	METER ON "T"	DATE & TIME	METER ORDER NO.	
REASON			FOLIO	COMP. LEDGER BY

CO'S NO.	KEY AT	LOC. BOOK NO.
		LOC. BOOK PAGE
SIZE	MOVED TO	FOLIO
INDEX	SEND BILL TO	CONS. LEG. LINE
REMOVED BY	CALL	ROUTE BOOK
DATE	GAS ON ... GAS OFF	LOC. BOOK FOLIO

Figure 181.—Meter Remove Card, page 573.

order, the fitter fills in the blank spaces on the order card, this including meter index and company number, and signs his name with date. On the return of his cards to the shop, the completed "Set" cards and any unused meters should equal the meters with which he is charged. Any discrepancy is looked up immediately. As an additional check against each meter set, the stock card referring to that meter is compared with the "Set" or "Change" card, after which the stock card is destroyed. If the

description on the stock card tallies with the description on the order card, it is perfectly safe to consider the information on the latter to be correct.

After a comparison has been made with the duplicate held by the shop, the completed meter cards are returned promptly to the commercial department, where the index and other desired information is entered in the consumers' ledger and the triplicates are destroyed. The cards are then forwarded to the main repair shop, where they are filed for a period of six years by serial order number, after the serial number, size, index, date and address have been entered on the location card for each meter in question. In the case of removed meters, there is a check on the information already posted from the meter test tag.

Each commercial office sends a daily report, on a special form, to the main repair shop, showing the serial order numbers, together with the nature of the order and the address, of all meter orders issued by the office during the preceding day. As the meter cards are received at the main repair shop, their numbers are checked off on these daily reports. The failure to receive any meter card is thus disclosed by an unchecked number, and a search is started after 60 days. This necessity for accounting for every meter card issued affords a check on both the distribution and the commercial department, and insures the receipt of every card by the main repair shop and the correct history of every meter on the location card.

In order to know the total number of meters set and removed each month, the daily sets and removals are listed in duplicate in each district. The original of each list is sent to the commercial department with the corresponding meter cards, and thus any loss of cards may be detected. The duplicates are kept until the end of the month, at which time a count is made of the number of meters set and removed and in stock, as shown by the stock cards, and the totals, entered by sizes, on the monthly meter report and sent to the main repair shop to be summarized by districts and forwarded to the commercial department.

From what has been written in this and in the preceding chapter, it is quite apparent that numerous checks are had on the meter index, and a careful and complete history kept of repairs and of the locations at which each meter has been set during its existence. For instance, in the case of a new meter, from the date of its purchase to its setting and subsequent

removal and return to the main repair shop, until it is again ready for shipment to a district shop, there are the following records showing the company number and index:

Record	Shows
Record Book	Number
Location Card	Number and Index
Repair Card	Number
Shipping List	Number and Index
Stock Card (originated)	" " "
Set Card	" " "
Consumers' Ledger	" " "
Location Card (checked with original entry)	" " "
Consumers' Ledger	" " "
Stock Card (originated)	" " "
Remove or Change Card	" " "
Test Sheet	" " "
Test Tag	" " "
Shipping List	" " "
Location Card	" " "

The question of the correct reading of a meter as set or removed, often arises after the index has been changed either through use or repair. It is quite important in such cases, involving, as they do, a difference of opinion between the consumer and the company, that the latter should have in its possession sufficient evidence to prove the correctness of the reading as originally taken. Below is shown the evidence available with the system of records already described:

For a "Set" card there is the entry on the —
- "Remove" card, if meter had been removed from another location previous to set.
- Test tag.
- "Set" card (checked against stock card).
- Consumers' ledger.
- Location card.

For a "Remove" card there is the entry on the —
- "Remove" card (checked against stock card).
- Test tag (checked against meter).
- Consumers' ledger.
- Location card.
- "Set" card, if no change in index had been made in the shop, and meter had been set before the question of reading arose.

In addition to "Set," "Change" and "Remove" cards, other cards are required for other phases of meter work. A "Turn-on" card is used when the meter is already in position but shut off. A "Shut-off" card is used when the meter is permanently shut off and allowed to remain in position. A "Change-of-Name" card is used when an application for gas is received from a new tenant, and no "Shut-off" card has been issued for the meter affected. The information on the above three cards is required by the commercial department for the correct rendering of bills. These cards are filed by that department.

In every case where it is necessary to go to the meter, certain data is entered on any orders held by the workman. This data furnishes information useful to the commercial department in checking consumption and meter locations.

Numerous other forms and records are needed in connection with meter work, but they are not mentioned here, for the intention has been to avoid too much detail, and to show, in a general way, only a system competent to secure correct meter records.

The meter order cards illustrated in this chapter are those used for ordinary meters in a situation owning both ordinary and prepayment meters. The corresponding cards for prepayment meters have the prefix "Prepaid," and are printed in red ink.

PART VIII

HOUSEPIPING AND FIXTURES

Under this heading will be given certain dimensions thought indispensable in fixture construction, and the general specifications which should govern the installation of housepiping and fixtures. The method of enforcement and the system of inspections described are those in use in Philadelphia, and are intended merely as a general guide. Under maintenance of housepiping, complaint work not relating to fuel or illuminating appliances will be described. In connection with this subject, the reader is referred to the report of the American Gas Institute's Committee on Gas Housepiping as printed on page 1014 of the 1916 Proceedings.

SECTION I

SPECIFICATIONS FOR PIPING AND FIXTURES

CHAPTER LIII

PIPING SPECIFICATIONS

Explanatory and Historical

The gas piping in a building is the final extension of the distribution system that begins at the holder outlet and, through mains and services, conveys the gas to and through the meter, at the outlet of which it enters the interior piping most commonly and conveniently known as housepiping. It is shown on page 63, in describing the design of a new main system, that the chief determinant for the size of pipe chosen is the loss in pressure available over the distance considered. The design of a house-piping system is governed similarly by the difference between the pressure available at the meter outlet and that required at the burner. There is no difference between the case of a main and that of a definite line of housepiping, but the problems presented by general housepiping are different and not so simple.

The above problem is one that faces every gas company, and upon its proper solution largely depends the satisfactoriness of supply. It is made more difficult through the prevailing ignorance of the public on physical matters generally. It is such ignorance that prevents the average person from appreciating that gas, though invisible, occupies space, and for the same loss in pressure the volume of gas delivered will vary with the diameter of the pipe. Most people who have an insufficient water supply understand that either the available pressure or the size of their water piping, or both of these reasons, cause the

trouble, but the majority of gas consumers attribute an unsatisfactory supply of gas, especially in the form of light, to a lack of *quality* instead of to the usual true cause,—insufficient *quantity.* Consequently, they are not apt to notify the gas company of their trouble because they suspect the company of deliberately supplying an inferior product. For this reason there is nothing more inimical to satisfactory service than the existence of piping too small to convey the gas required through it. The company may have a splendid system of mains and services and every consumer have ample pressure at his meter outlet, but if the majority of the buildings contain piping of inadequate size, the service can not be satisfactory.

The foregoing has attempted to make clear both the necessity of proper housepiping and also the impelling reason for each company to strive in every possible way to secure such housepiping in its area of supply. In some situations, either indirectly through municipal officials, or directly through their own inspectors, the companies have full control and are able to obtain their requirements by the power of otherwise refusing a supply. In other places, persuasion alone is possible, and in these communities many consumers pay the penalty of their own ignorance and the parsimony of the builder. For our present purpose, however, we assume that the gas company has the requisite power, and will proceed to discuss the form in which it should convey its requirements for pipe sizes, this being the general housepiping problem already referred to.

Let us suppose that the pressure available at each meter outlet will enable a drop of 0.4 inch through the housepiping. Then, for any definite system of housepiping, the correct particular solution would be obtained by selecting such increasing sizes of pipe, starting from the farthest outlet and proceeding to the meter, as would give throughout the entire length approximately the same drop in pressure through each unit of distance. If the extreme distance from the farthest outlet to the meter is 100 feet, the uniform loss in pressure should be 0.4 inch divided by 100, or 0.004 inch for each foot of run. Knowing the amount of gas desired at each point of consumption, the correct pipe sizes will be readily shown by the computer. Such an individual solution for each building is, however, out of the question under the conditions that obtain in practice, where the pipe sizes must be determined by the average plumber to whom the use of a computer would present insuperable difficulties.

Fortunately, the great majority of piping systems, while differing in small particulars, are, in their general features, so uniform that it is possible to provide adequate and fairly consistent regulations for an entire community, in such a form as may be generally understood by the workmen for whose use they are intended; thus leaving only a small minority of buildings for which individual solutions are desirable.

The first general form of housepiping table is given in "King's Treatise on the Science and Practice of the Manufacture and Distribution of Coal Gas," Volume III, page 33, as quoted below:

> "The following are the sizes and lengths of iron, lead or composition tubes to be used, according to the number of lights:

A	B	C	D	E
			Pressure Drop (Inches of Water)	
Internal Diameter of Tubing	Greatest Length Allowed	Greatest Number of Burners Allowed	For Fifty Feet of Run	For Greatest Length Allowed
$\frac{3}{8}''$	20′	3	.125″	.05″
$\frac{1}{2}''$	30′	6	.125″	.07″
$\frac{5}{8}''$	40′	12	——	——
$\frac{3}{4}''$	50′	20	.160″	.16″
1″	70′	35	.125″	.17″
$1\frac{1}{4}''$	100′	60	.125″	.25″
$1\frac{1}{2}''$	150′	100	.125″	.40″
2″	200′	200	.125″	.54″

> "Tubing $\frac{1}{4}$-inch bore is not allowed to be used under any circumstances."

The text in quotation marks and Columns A, B and C of the above table are quoted verbatim. Columns D and E have been added for the convenience of further explanation. The pressure drop in both is obtained by a computer, assuming an hourly consumption of 5 cubic feet per burner and a specific gravity of .46 for the coal gas universally supplied 50 years ago. Column D shows that for each size of pipe, the allowable loss in pressure for each 50-foot run is 0.125 inch, excepting only $\frac{3}{4}$-inch size, when the loss is 0.16 inch. The consumption allowed for this size is the one inconsistent feature of the table, and to be uniform with the other sizes, the greatest number of burners allowed should have been 17.

It is evident that King's table would have the general effect of limiting the loss of pressure in housepiping to 0.125 inch per

50 lineal feet, so that in 200 feet the drop would not exceed 0.5 inch. While this drop is somewhat larger than that usually available for housepiping, it will be seen later that 200 feet is more than twice the average distance in the usual system of piping between the farthest outlet and the meter, and, therefore, the maximum number of burners allowed for each size of pipe was wisely chosen. Also, in determining the greatest length allowed, it is clear that the author of the table had in mind the necessity of limiting the total possible drop in any one system, and, therefore, in each pipe size.

TABLE FOR HOUSEPIPING

PROPOSED BY RESEARCH COMMITTEE

$$Q = 1350\sqrt{\frac{d^5 p}{\frac{1}{3} l g}}$$

Loss of pressure assumed 1/10-inch of water for 50 feet of pipe.
d = diameter in inches.
p = pressure in inches of water.
l = length of pipe in feet.
g = specific gravity of gas compared with air.
Q = cubic feet of gas per hour.
"g" assumed to be .680.
"d" and "l" assumed. "Q" calculated.

A	B	C	D	E
			Pressure Drop (Inches of Water)	
Diameter of Pipe	Length of Pipe	Cu. Ft. of Gas Per Hour	For Fifty Feet of Run	For Greatest Length Allowed
⅜″	20′	11	.10″	.04″
½″	30′	22	.10″	.06″
¾″	50′	60	.10″	.10″
1 ″	70′	127	.10″	.14″
1¼″	100′	222	.10″	.20″
1½″	150′	349	.10″	.30″
2 ″	200′	718	.10″	.40″
2½″	300′	1253	.10″	.60″
3 ″	450′	1977	.10″	.90″
4 ″	600′	4059	.10″	1.20″

"The third column gives the maximum duty per hour for pipe of the length and diameter given.

"No greater length of pipe should be used than is given in the table; e. g., the maximum length of 1-inch pipe allowable under any circumstances is 70 feet, and it should not be expected to carry over 127 cubic feet of gas per hour."

King's table was, at the time of its appearance, such a step in advance that it was universally accepted where regulation of

housepiping was attempted, and even in later years, with the adoption of a modified form, there has been no departure from the maximum allowable lengths. In this country King's table was the only authority until after the 1898 meeting of the American Gas Light Association, at which the standard on page 584 was adopted. For present convenience, it is not shown in the exact form printed on page 75 of Volume 15 of the Association's Proceedings, and Columns D and E have been added for comparison with the preceding table.

This Association table was designed for the use of straight carburetted water gas, and does not allow as much drop per lineal foot as does King's table. The effect of both of these changes is to reduce by 30 per cent the allowable consumption through a given size pipe. (All this on the previous assumption that each burner in King's table should be taken as the equivalent of 5 cubic feet per hour.) Such a decrease was amply justified in view of the tremendous cheapening in the cost of small piping since the publication of King's table, and of the prospect, plainly evident even in 1898, that after a system of housepiping had been designed and completed for the outlets as planned, the increasing use of gas for fuel purposes would result in a much larger demand at certain outlets than could be then foreseen.

As soon as much thought was given to the application of either of the two preceding tables to the control of housepiping throughout a community, it was evident that they were faulty in certain respects. These faults may be understood better if we follow a plumber in proceeding to determine the size of housepiping. He would start from the farthest point and work to the meter. This point would be for him an opening in the piping, or, in other words, an "outlet," and not a burner as in King's table nor a certain number of cubic feet as in the Association table. Therefore, the model table should show gas quantity in "outlets." In fixing on the size and allowable length of piping from the first to the second outlet, the plumber would have no trouble, but as he proceeded toward the meter and for each successive outlet passed, had to include its consumption in the gas which was to flow through the particular piece of pipe whose size was to be determined, his difficulties in working from either of the two old tables would increase. What he needs is a table in such a form as to show at once the size of pipe required for any desired number of outlets. Such a table is that which has been in use in Philadelphia for 18 years, and which is now given.

Piping Schedule

Sizes

REQUIRED SIZES OF PIPING FOR VARIOUS LENGTHS AND NUMBERS OF OUTLETS

No. of 3/8 In. Outlets	Size of Pipe in Inches: 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
	Length of Pipe in Feet									
1	20	30	50	70	100	150	200	300	400	600
2		27	50	70	100	150	200	300	400	600
3		12	50	70	100	150	200	300	400	600
4			50	70	100	150	200	300	400	600
5			33	70	100	150	200	300	400	600
6			24	70	100	150	200	300	400	600
7			18	70	100	150	200	300	400	600
8			13	50	100	150	200	300	400	600
9				44	100	150	200	300	400	600
10				35	100	150	200	300	400	600
11				30	90	150	200	300	400	600
12				25	75	150	200	300	400	600
13				21	60	150	200	300	400	600
14				18	53	130	200	300	400	600
15				16	45	115	200	300	400	600
16				14	41	100	200	300	400	600
17				12	36	90	200	300	400	600
18					32	80	200	300	400	600
19					29	73	200	300	400	600
20					27	65	200	300	400	600
21					24	58	200	300	400	600
22					22	53	200	300	400	600
23					20	49	200	300	400	600
24					18	45	190	300	400	600
25					17	42	175	300	400	600
30					12	30	120	300	400	600
35						22	90	270	400	600
40						17	70	210	400	600
45						13	55	165	400	600
50							45	135	330	600
65							27	80	200	600
75							20	60	150	600
100								33	80	360
125								22	50	230
150								15	35	160
175									28	120
200									21	90
250									14	59
300										39
350										29
400										22
600										14

If any outlet is larger than 3/8 inch, it must be counted as more than one, in accordance with the schedule below:

Size of outlet in inches	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
Value in 3/8-in. outlets	2	4	7	11	16	28	44	64	112

A comparison of the three tables will show at once the more expanded form of the latest one. In an article, "Notes on Housepiping," in the American Gas Light Journal of February 2, 1903, page 162, there is a discussion of the differences between the table (in a less expanded form) and the Association table. Some of the statements there made will be repeated here. The Philadelphia table accepts the limiting lengths of the previous tables, and also the constant of 1350. The other lengths are obtained by assuming 10 cubic feet per outlet, a specific gravity of .65 (for Philadelphia conditions), a "section" drop of 0.04 inch, and a limiting drop of 0.10 inch in 30 feet. (A "section" is the length measured from one branch or point of junction to another, disregarding elbows or turns.) This last, it will be noted, is greater than in either of the older tables, but it is fully compensated for by the fact that in practice each outlet will not require 10 cubic feet and the maximum length of a section is seldom used. It is in its use of sections that the Philadelphia table sharply differentiates itself from the two preceding forms, and becomes more suitable for the design of large systems, which are unduly penalized by the older tables. As the loss in each section is limited to 0.04 inch, in a 10-section house the maximum drop would be 0.4 inch. In Philadelphia, the average house does not contain 10 sections, nor are all of the sections located in the main line between the furthest outlet, or the largest outlet or number of outlets, and the meter. Because the limit of pressure drop is 0.1 inch in 30 feet, the section length may be never less than 12 feet, and this results, as is quite desirable, in causing the change in pipe size to occur generally at branch or outlet fittings, because the average distance between outlets in adjoining rooms is more than 12 feet. Though because of the rule for section loss, the Philadelphia table allows, in most cases, a shorter length of pipe than is permitted by the Association table, yet in practical working, as will be seen later on, this does not result in increased pipe sizes throughout a building.

In compiling the table, the standard maximum lengths for each size pipe were placed in the line opposite "1" outlet, and were continued down the table for increasing outlets until, for each size of pipe, a smaller length was required to satisfy the rule of no section drop greater than 0.04 inch. For instance, to find the length of $\frac{3}{4}$-inch pipe suitable for five outlets, $\frac{3}{4}$-inch is set at 50 cubic feet, and it is found that a 0.04 inch drop is

obtained with 33 feet, which is, therefore, the maximum length allowable, and not 50 feet. Continuing in this way for $\frac{3}{4}$-inch, when we reach nine outlets, and therefore set $\frac{3}{4}$-inch opposite 90 cubic feet, we discover 0.04 at 10 feet, but as 0.1 inch is at 24 feet, we cannot allow the use of 10 feet of $\frac{3}{4}$-inch pipe for nine outlets, as this would cause a pressure drop exceeding 0.1 inch in 30 feet.

To compare the practical application of the Association and the Philadelphia tables, the following examples for actual house-piping plans are given:

PLAN I

A	B	C	D	E	F
No. of Outlets	Length of Pipe	Size of Pipe		Pressure Drop (Inches of Water)	
1	20′ 7″	$\frac{1}{2}$″	$\frac{1}{2}$″	.008″	.008″
2	4′ 2″	$\frac{1}{2}$″	$\frac{1}{2}$″	.007″	.007″
3	2′ 7″	$\frac{3}{4}$″	$\frac{1}{2}$″	.004″	.009″
5	2′ 11″	$\frac{3}{4}$″	$\frac{3}{4}$″	.006″	.006″
6	6′ 4″	$\frac{3}{4}$″	$\frac{3}{4}$″	.011″	.011″
7	8′ 8″	1 ″	$\frac{3}{4}$″	.006″	.020″
8	2′ 7″	1 ″	$\frac{3}{4}$″	.004″	.008″
9	2′ 9″	1 ″	1 ″	.005″	.005″
10	25′ 0″	1 ″	1 ″	.028″	.028″
	75′ 7″			.079″	.102″

PLAN II

A	B	C	D	E	F
No. of Outlets	Length of Pipe	Size of Pipe		Pressure Drop (Inches of Water)	
1	11′ 6$\frac{1}{2}$″	$\frac{3}{8}$″	$\frac{3}{8}$″	.017″	.017″
2	11′ 6$\frac{1}{2}$″	$\frac{1}{2}$″	$\frac{1}{2}$″	.017″	.017″
3	11′ 6$\frac{1}{2}$″	$\frac{3}{4}$″	$\frac{1}{2}$″	.005″	.038″
4	11′ 6$\frac{1}{2}$″	$\frac{3}{4}$″	$\frac{3}{4}$″	.009″	.009″
5	9′ $\frac{1}{2}$″	$\frac{3}{4}$″	$\frac{3}{4}$″	.011″	.011″
8	2′ 0 ″	1 ″	$\frac{3}{4}$″	.004″	.007″
9	4′ 3 ″	1 ″	1 ″	.006″	.006″
10	4′ 1$\frac{1}{4}$″	1 ″	1 ″	.007″	.007″
11	2″ 1 ″	1 ″	1 ″	.005″	.005″
16	3′ 5 ″	1$\frac{1}{4}$″	1$\frac{1}{4}$″	.004″	.004″
17	2′ 7 ″	1$\frac{1}{4}$″	1$\frac{1}{4}$″	.004″	.004″
18	7′ 3 ″	1$\frac{1}{4}$″	1$\frac{1}{4}$″	.009″	.009″
19	0′ 8 ″	1$\frac{1}{4}$″	1$\frac{1}{4}$″	.003″	.003″
20	5′ 2 ″	1$\frac{1}{4}$″	1$\frac{1}{4}$″	.008″	.008″
	86′ 8$\frac{3}{4}$″			.109″	.145″

Plan III

A	B	C	D	E	F
No. of Outlets	Length of Pipe	Size of Pipe		Pressure Drop (Inches of Water)	
1	7′ 0″	$\frac{3}{8}$″	$\frac{3}{8}$″	.011″	.011″
2	9′ 2″	$\frac{1}{2}$″	$\frac{1}{2}$″	.013″	.013″
4	9′ 10″	$\frac{3}{4}$″	$\frac{3}{4}$″	.008″	.008″
5	11′ 3″	$\frac{3}{4}$″	$\frac{3}{4}$″	.013″	.013″
10	8′ 8″	1 ″	1 ″	.010″	.010″
17	11′ 0″	$1\frac{1}{4}$″	$1\frac{1}{4}$″	.010″	.010″
20	4′ 4″	$1\frac{1}{4}$″	$1\frac{1}{4}$″	.008″	.008″
	61′ 3″			.073″	.073″

Plan IV

A	B	C	D	E	F
No. of Outlets	Length of Pipe	Size of Pipe		Pressure Drop (Inches of Water)	
1	7′ 0″	$\frac{3}{8}$″	$\frac{3}{8}$″	.011″	.011″
2	9′ 3″	$\frac{1}{2}$″	$\frac{1}{2}$″	.013″	.013″
3	8′ 6″	$\frac{3}{4}$″	$\frac{1}{2}$″	.005″	.028″
5	7′ 0″	$\frac{3}{4}$″	$\frac{3}{4}$″	.008″	.008″
6	3′ 1″	$\frac{3}{4}$″	$\frac{3}{4}$″	.005″	.005″
8	8′ 6″	1 ″	1 ″	.009″	.040″
23	8′ 6″	$1\frac{1}{2}$″	$1\frac{1}{4}$″	.007″	.016″
27	1′ 6″	$1\frac{1}{2}$″	$1\frac{1}{4}$″	.004″	.006″
45	8′ 6″	2 ″	$1\frac{1}{2}$″	.007″	.025″
49	1′ 6″	2 ″	2 ″	.003″	.003″
68	8′ 6″	2 ″	2 ″	.013″	.013″
72	1′ 6″	2 ″	2 ″	.004″	.004″
90	8′ 6″	$2\frac{1}{2}$″	$2\frac{1}{2}$″	.008″	.008″
94	1′ 6″	$2\frac{1}{2}$″	$2\frac{1}{2}$″	.003″	.003″
112	8′ 6″	$2\frac{1}{2}$″	$2\frac{1}{2}$″	.012″	.012″
116	1′ 6″	$2\frac{1}{2}$″	$2\frac{1}{2}$″	.004″	.004″
134	8′ 6″	3 ″	$2\frac{1}{2}$″	.008″	.017″
154	14′ 6″	3 ″	3 ″	.015″	.015″
180	1′ 0″	3 ″	3 ″	.004″	.004″
203	9′ 2″	4 ″	3 ″	.006″	.017″
205	15′ 8″	4 ″	3 ″	.008″	.030″
209	32′ 3″	4 ″	4 ″	.016″	.016″
448	8′ 6″	6 ″	4 ″	.004″	.016″
	182′ 3″			.177″	.314″

In each table, the outlets in Column A are those supplied by the sections of pipe whose length is given in Column B. Column C shows the sizes of pipe required by the Association table for the section in question, and Column E, the corresponding loss (in inches of water) of pressure through the section. Columns D and F show the same data for the Phila-

delphia table. Plan I is for a five to seven-room house, of which several thousand are built in Philadelphia every year. Plans II and III are the larger houses, of eight to twelve rooms, while Plan IV is of a very large apartment house. In none of the four plans is the drop allowed by the Philadelphia table too much, and yet the latter table, it will be noted, allows, in several cases, the use of smaller pipe than does the Association table. Plan IV illustrates very well the unnecessary rigor of the Association table, as the latter requires one section of 6-inch and three of 4-inch, compared with the two sections only of 4-inch necessary to comply with the Philadelphia table, and yet the total drop for the latter table is only slightly over three-tenths of an inch.

Supplementary Size Data

In using the schedule, the following rules should be observed:

(*a*) No piping between the meter and the first branch line should be smaller than $\frac{3}{4}$-inch,

(*b*) No piping should be smaller than $\frac{3}{8}$-inch.

(*c*) No independent line in the cellar or on the first floor, from the meter to a gas range should be smaller than 1 inch, but when the range is supplied from the housepiping, a $\frac{3}{4}$-inch outlet will suffice. Above the first floor, an independent line from the meter to a gas range on an upper floor should be not smaller than $\frac{3}{4}$-inch. No pipe laid under ground should be smaller than $1\frac{1}{4}$ inches. No pipe extending outside of the main wall of a building should be smaller than $\frac{3}{4}$-inch.

(*d*) No ceiling outlet where the height of the ceiling is 20 feet or more, should be smaller than $\frac{3}{4}$-inch.

(*e*) Piping for any type of room heater, except gas logs, over 18 inches in length, and where line does not exceed 9 feet in length, should be not less than $\frac{1}{2}$-inch. For similar installations with line exceeding 9 feet, the size should be not less than $\frac{3}{4}$-inch, but a short vertical pipe through the floor may be $\frac{1}{2}$-inch. In other cases, and where the housepiping is to supply fuel appliances other than ranges, the hourly consumption of the appliance should be used in determining the proper size of piping. In any case, the capped outlet should be not more than 2 inches nor less than $\frac{5}{8}$-inch above the floor level.

(*f*) Never supply gas from a smaller size pipe to a larger one. This does not apply to the case of a small pipe inside of a building supplying one outside of a building, which has been made large as per rule (*c*).

(*g*) When, in following the requirements of the schedule, 2-inch pipe or larger is required, and objectionable cutting of joists will be necessary, and it is believed the quantity of gas to be consumed is less than that contemplated in the table, a reduction in piping size should be considered.

Use of Schedule

(*h*) In determining the sizes of piping, always start at the extremities of the system and work toward the meter.

(*i*) The lengths of piping to be used in each case are the lengths measured from one branch or point of junction to another, disregarding elbows or turns. Such lengths will be hereafter spoken of as "sections," and are ordinarily of one size of pipe. There are only two reasons for which a change in size of piping should be allowed in a section: first, where the length of a section is greater than the length allowed for the outlets being supplied; as, for example, if a section supplying two outlets is 33 feet long, 27 feet of this could be ½-inch, and the remaining 6 feet, ¾-inch; second, where the required length for the outlets being supplied will cause a violation of rule (*j*) unless the size is changed.

(*j*) If the exact number of outlets under consideration cannot be found in the schedule, take the next larger number. For example, if 27 outlets are required, the next larger number in the schedule, which is 30, should be taken.

(*k*) For any given number of outlets, do not use a smaller size pipe than the smallest size in the schedule for that number of outlets. Thus, to supply 17 outlets, no smaller size pipe than 1 inch may be used, no matter how short the section may be.

(*l*) In any piping plan, in any continuous run from an extremity to the meter, there should not be used a longer length of any size pipe than shown for that size in the line opposite 1 outlet: as 50 feet for ¾-inch, 70 feet for 1-inch, etc. Exceptions to this rule are: first, when larger piping than called for by the schedule is run in following (*k*); second, when fitter voluntarily runs a larger size than is necessary; as, for example, if three outlets are to be supplied by 60 feet of piping, instead of 50 feet of ¾-inch and 10 feet of ½-inch being required, the entire 60 feet may be of ¾-inch piping. When two or more successive sections work out to the same size of piping, and their total length or sum exceeds the longest length shown for that size piping, the change in size to a larger pipe should be made as soon as the limiting length has been reached. For example, if five outlets are to be supplied through 30 feet of piping, and then these five and one more, making six in all, through 24 feet of piping, it would be found by the schedule that five outlets through 30 feet require ¾-inch piping, and that six outlets through 24 feet require ¾-inch piping, but as the sum of the two sections, 30 plus 24 equals 54, is 4 feet longer than the amount of ¾-inch piping that may be used in any continuous run, the 24-foot section must be changed from ¾-inch to 1 inch, 4 feet from the end nearest the meter.

Installation Requirements

Mains or Risers

Where there is only one vertical main in a building, it should extend to a point within 24 inches (measured in a horizontal direction) of a vertical line from the head of the service.

If the service has not been installed, its location should be decided upon, so that the vertical main can be properly located and plans made.

Where a building is to be occupied by more than one tenant, the company should set as many meters as there are separate consumers, but each meter should be located within sight of the end of the service; therefore, for every separate meter desired, a riser should be provided. These risers may drop to the basement at whatever points in the building are most convenient, a clear space of not less than 3 inches, however, being maintained between any two of these vertical pipes. Risers which drop at points in the building that are not in the proximity of the proposed location of the meters, should be extended horizontally. The distance from the service at which these risers should terminate will vary with different buildings.

A riser should never be located in a window box (the space between the inside finish and the outside wall at either end of a bulk window) nor come down an exposed wall, nor be within 2 feet of the latter if there is an inside partition or wall that may be used; if none is available, it should come down near a chimney on the exposed wall. A riser should not extend more than 3 inches, nor less than 2 inches, below the bottom of the joist. If the riser must be extended horizontally, in order to terminate as specified, a tee, with plug looking down, should be put on the bottom of the vertical pipe, and should end in such a place that beams, girders, heater pipes, etc., to be put up subsequently, would not prevent making connections to the meter. Where it is necessary to offset the riser, due to the projection of the foundation wall beyond the house wall, such offset should be made by using, at the upper end of the offset, a 45° elbow, placed so as to bring the riser clear of the edge of the foundation wall and at the lower end a Y fitting with a plugged outlet looking down. The dropping of a riser down to the ledge of the foundation wall and the use of a 90° elbow to come out is not good practice.

Building Services

The preceding paragraphs describe the regulations proper for a situation where most of the dwellings are one-family houses, and where the comparatively few apartment houses are three stories or less and do not average over six separate apartments. In a city where apartments are the rule, and are of many stories, and each contains a large number of separate families,

the economic advantages of a "building service" rising pipe, containing unmeasured gas and serving as a continuous supply to many apartments, outweighs the advantage to the gas company of locating each meter within sight of the service head. The use of prepayment meters, and in many cases, the inability of each tenant to gain access to the cellar, are also decisive reasons why cities of apartment houses, such as New York, Chicago, etc., need different meter location rules from Philadelphia. The rules in use in these cities are readily obtainable from the local gas companies.

The existence of loft buildings, occupied by many tenants, each requiring a separate gas supply, is also an adequate reason for a "building service" in these buildings. The recommendations of the Committee on Gas Housepiping for "building services" are given below.

Size

The gas company should be consulted as to the size of a building service.

Location

Under all conditions the building service should terminate within 3 feet of the proposed location of the street service.

Header

When it is necessary to set more than two meters together, a building service header should be supplied, with an opening for each meter, which openings should be not less than 18 inches apart.

Opening

The opening in a building service should be on the left-hand side of the riser which it is to supply, and not less than 18 inches from it.

Grading

A building service should be graded to the street, and in any horizontal run, the tee left turned up, so that any condensation forming in the pipe may run to the street and not to the meter.

Covering

A building service exposed to freezing temperatures should be properly protected, in a manner satisfactory to the gas company. If insulating covering is used, it should be incombustible.

Outlets

Ceiling

Ceiling outlets should project not more than 2 inches, nor less than $\frac{5}{8}$-inch, and should be at right angles to the ceiling, and firmly secured.

Wall

Wall outlets should project not more than $\frac{7}{8}$-inch, nor less than $\frac{5}{8}$-inch, and should be at right angles to the wall, and firmly secured.

Mantel

An outlet for a mantel or fireplace should project $1\frac{1}{2}$ inches above the finished bottom of the fireplace, and be located 6 inches from the back and left-hand side of the fireplace.

Illumination

Outlets for illumination should not be placed in any location where good practice forbids, and the gas company should reserve the right to reject any piping where the outlets are placed in unsatisfactory locations.

Fuel

If the pipe has been run under and up through the floor, the outlet should be 3 inches above the floor and 2 inches clear of the baseboard. If in the kitchen the pipe has been run overhead and down the wall, the outlet should be 3 feet from the floor, and should project 2 inches horizontally from the wall. If in other rooms the pipe has been run overhead and down, the outlet should be on the baseboard 3 inches above the floor, and unless a drop tee or ell is used, should be 2 inches clear of the baseboard.

Accessibility

It is important, for the purposes of cleaning and repairing, that the piping be as accessible as possible.

In buildings of the ordinary construction, with flooring of single thickness laid across the joists, and with ceilings lathed and plastered below the joists, the horizontal piping should be located parallel to and just under the floor boards, passing over the joists, which should be notched as little as possible; and where the pipes are of large sizes, the joists should be notched near their points of support in order to weaken them the least.

In buildings where the floors are so constructed that piping placed under them would be difficult and expensive to uncover, such as tile, mosaic, parquetry, double or diagonal flooring, etc.,

the piping should not be so placed if it can be avoided; in some cases, the piping may be left exposed below the ceiling; in case the beam, girders or joists are to be left exposed, the piping may be placed in an angle and concealed by moulding; in case the piping must be concealed in the floor, it should not be located at the bottom of beams or joists which are lathed and plastered to form the ceiling, but placed above the supporting beams, just under the floor covering, in grooves formed in the material on which the floor covering is laid, or, in case of cement floors, imbedded in the cement. In some cases, the beams may be notched, or iron beams drilled through their webs, near their points of support.

Vertical pipes, if they must be concealed, should, as far as possible, be located in hollow partitions, in preference to being placed in the studding or lathing back of the plaster on masonry walls.

It is good practice, where pipes pass through masonry walls and concrete floors, to have them incased in a pipe of such diameter as to give a clearance of $\frac{1}{4}$-inch all around.

Protection

When necessary to imbed a pipe in direct contact with neat cement or ordinary concrete, black pipe may be used. If cinders, salt, sea water, or other substance which has a corrosive action on the piping, is to be used in the fabrication of the cement or concrete, or if the concrete or cement in which the pipe is laid is to be exposed to brine, acid, pickling-bath liquor, or other liquids of a corrosive nature, or if the pipe is to be in contact with composition flooring or similar structural material, the piping should be made up of pipe and fittings both galvanized, and should be painted with two coats of a pure red-leaded paint, a bituminous paint, or an equivalent protective coating. It is preferable that it also be wrapped or coated with an approved material for protection against corrosion.

Support

In buildings constructed with wooden floor joists and wooden framework in partitions, the piping should be rigidly supported by hooks, or straps, which are nailed or screwed to woodwork, or, in the case of masonry walls, to wooden plugs inserted in these walls. These points of support, for vertical and for horizontal piping, should be spaced as follows:

Size of Pipe	Horizontal Piping	Vertical Piping
$\frac{3}{8}''$	6′	10′
$\frac{1}{2}''$	6′	10′
$\frac{3}{4}''$	8′	—
1″	8′	—
$1\frac{1}{4}''$ or larger	10′	Every floor level

Where piping is not located sufficiently close to the woodwork to admit of secure fastening, additional wooden strips, spaced in accordance with the preceding table, should be provided. These strips should be supported at their ends by nailing or screwing to wooden cleats, which in turn are nailed or screwed to the joists or studding.

In buildings where iron beams, concrete or tiling enter into the construction of floors or partitions, the piping, whether concealed or exposed, should be supported rigidly, and in the most accessible location possible.

The fittings that are back of all outlets, whether ceiling outlets or side wall outlets, should be firmly and rigidly attached by flanges, hooks or straps to the framework of the building. If there is no adequate support located back of the point where the outlet is desired, a strap should be provided, supported as described above.

Slope

The piping should slope toward the meter, or toward an outlet from which condensation can be removed if necessary; or it may be laid level. Piping should not be installed with a perceptible sag, as condensation might collect there. It is especially important that underground piping be laid in such a way that condensation may be readily removed.

Jointing

White lead or other jointing material should be used sparingly, to avoid clogging the pipe. Jointing material always should be put on the male thread and not in the fitting. Gas fitters' cement should not be used.

Obstructions

The piping should be free from obstructions. Every piece of pipe should be stood on end and thoroughly hammered, and also blown through, before being connected. After being connected, all piping should be blown through from the last outlet on each floor to the lower end of the riser, to make sure it is clear. No piping should be coated or painted until inspected and

passed. Long screws, or right and left-hand couplings, instead of unions, should be used in concealed work.

Miscellaneous

All branches should be taken from the sides or top of the running line, and not from the bottom.

Bending pipe to form outlets, or for other purposes as approved by the company, should be permitted. In bending pipe care must be taken that it does not kink. Pipe excessively flattened, or bent to less than the radii given below, will not be permitted.

Size of Pipe	Minimum Radius of Bend
$\frac{3}{8}''$	3″
$\frac{1}{2}''$	4″
$\frac{3}{4}''$	5″
1″	6″
$1\frac{1}{4}''$	8″
$1\frac{1}{2}''$	10″
2″	14″

Inspection Requirements

After piping has been installed, it should be inspected and tested by the proper authorities in accordance with the rules in Chapter LV, qualified by the following requirements:

In joining new extensions to [1]old piping, the fitter should examine carefully the sizes of that portion of the old piping through which the gas will flow on its way to the extension, in order to make sure that it is of sufficient size to supply the new outlets in addition to the old ones. If the sizes of the old piping are not in exact accordance with, but do not differ widely from, the requirements of the schedule, connection may be made thereto.

A system of [2]new piping that is to be joined to a system of old piping, thus constituting an extension to the old piping, requires the regular first inspection before being joined to the old piping. After the certificate is issued on this first inspection, and the new piping is connected to the old piping, another inspection should be made, in which the whole enlarged system of piping will be required to stand a pressure of 6 inches of water column, showing

1 The term "old piping" designates all piping found on the premises when the existing job is undertaken, and it may or may not have gas in it; or it may or may not have been previously inspected.

2 The term "new piping" designates only that piping that is installed as a part or all of the existing job.

no drop in 10 minutes. This applies whether or not any fixtures are on the old or new systems of piping.

Where the work has consisted of the blowing out of an old system of piping, the removal and replacement of some parts of it, the insertion of some new piping in place of old piping, or the extensions to new outlets where each extension consists of a line of pipe to only one new outlet, as distinguished from an extension consisting of a system of piping which leads to more than one new outlet, the third inspection only should be required.

When these classes of work are contemplated, it is advisable that the fitter test the old system of piping for leaks before estimating on the cost of the work.

Piping Plan

When the housepiping is inspected by the local gas company and it is required that a plan be submitted showing the proposed layout with length and sizes, the company should supply to the fitters, a form for this purpose, printed on white cross section paper, 9 by 15 inches, with $\frac{1}{4}$-inch ruling. This form is shown in Figure 182.

Explanation of Assumed Plan

Beginning, Figure 183, at the point 1, which is farthest from the meter, piping 1 A, being 4 feet 6 inches long, and supplying the (one) outlet 1, should be $\frac{3}{8}$-inch. Piping 2 A, being 1 foot long and supplying the (one) outlet 2, should also be $\frac{3}{8}$-inch. Piping A B, being 12 feet long, and supplying the (two) outlets 1 and 2, should be $\frac{1}{2}$-inch.

Piping 3 D, supplying the (one) outlet 3, and being 24 feet long, exceeds the maximum length of $\frac{3}{8}$-inch permitted to supply one outlet, and, therefore, the distance 3 C should be composed of 20 feet of $\frac{3}{8}$-inch, and the remaining distance C D should be composed of 4 feet of $\frac{1}{2}$-inch. Piping 4 D, being 8 feet long, and supplying the (one) outlet 4, should be $\frac{3}{8}$-inch. Piping D B, being 1 foot long, and supplying the (two) outlets 3 and 4, should be $\frac{1}{2}$-inch.

Piping B E, being 25 feet long, and supplying the (four) outlets 1 to 4 inclusive, should be $\frac{3}{4}$-inch.

Piping 5 E, being 7 feet long, and supplying the (one) outlet 5, should be $\frac{3}{8}$-inch.

Piping E G, being 30 feet long, and supplying the (five) outlets 1 to 5 inclusive, cannot be composed entirely of $\frac{3}{4}$-inch,

as only 50 feet of $\frac{3}{4}$-inch is permitted in a continuous run to the meter, and as 25 feet has been already used in the section B E, therefore, the distance E F should be composed of 25 feet of

PIPING PLAN

DRAW PLAN ON OTHER SIDE

ADDRESS OF JOB ....

PLUMBER'S { NAME .... ADDRESS ....

BUILDER'S OR OWNER'S { NAME .... ADDRESS ....

REMARKS ....

....

....

....

IMPORTANT INSTRUCTIONS

SEND THIS PLAN TO THE DISTRICT SHOP LOCATED IN THE SAME DISTRICT IN WHICH THE WORK IS DONE.

ALWAYS GIVE THE NUMBER FOR A CORNER ADDRESS.

IN PREPARING A PLAN, THE FOLLOWING INSTRUCTIONS SHOULD BE STRICTLY ADHERED TO:

(A) Vertical Piping should be shown parallel to the Short Side of the Sheet.

(B) Piping through the length of the Building should be shown parallel to the Long Side of the Sheet.

(C) Piping across the width of the Building should be shown diagonally on the Sheet.

(D) State Length and Size of each Section of Piping. A Section designates the Length of Piping existing between Outlets, Fittings and Points of Changes in Piping Sizes.

(E) On Horizontal Piping, mark the Length under the Line, and Size over the Line.

(F) On Vertical Piping, including Drops, mark the Length to the Right of the Line, and the Size to the Left of the Line.

(G) Mark each Outlet X, and in the case of a Plugged Outlet, state its Size.

(H) Plan should be Folded on Dotted Line.

Figure 182.—Housepiping Sheet, page 598.

$\frac{3}{4}$-inch, and the remaining distance F G should be composed of 5 feet of 1-inch.

Piping 6 G, being similar to 5 E, should be $\frac{3}{8}$-inch.

Piping G H, being 1 foot long, and supplying the (six) outlets, 1 to 6 inclusive, should be 1-inch, because, even though $\frac{3}{4}$-inch, according to the schedule, is permitted to supply six outlets, the maximum amount of $\frac{3}{4}$-inch permitted has already been used in the distance B F.

Piping 7 J, being 15 feet long, and supplying the (one) outlet 7, should be $\frac{3}{8}$-inch. Piping 8 J, being 3 feet 6 inches long, and supplying the (one) outlet 8, should be $\frac{3}{8}$-inch. Piping J K, being 3 feet long, and supplying the (two) outlets 7 and 8, should be $\frac{1}{2}$-inch. Piping 9 K, being 4 feet 6 inches long, and supplying the (one) outlet 9, should be $\frac{3}{8}$-inch. Piping K H, being 25 feet long, and supplying the (three) outlets 7 to 9 inclusive, exceeds the maximum length of $\frac{1}{2}$-inch permitted to supply three outlets, and, therefore, the distance K L should be composed of 12 feet of $\frac{1}{2}$-inch, and the remaining distance L H should be composed of 13 feet of $\frac{3}{4}$-inch.

Piping H N, being 19 feet long, and supplying the (nine) outlets 1 to 9 inclusive, should be 1-inch.

Piping 10 M, being 12 feet 6 inches long, and supplying the (one) outlet 10, should be $\frac{3}{8}$-inch. Piping 11 M, being 7 feet 6 inches long, and supplying the (one) outlet 11, should be $\frac{3}{8}$-inch. Piping M N, being 7 feet long, and supplying the (two) outlets 10 and 11, should be $\frac{1}{2}$-inch.

Piping N O, being 1 foot 6 inches long, and supplying the (eleven) outlets 1 to 11 inclusive, should be 1-inch.

Piping 12 O, being 9 feet long, and supplying the (one) outlet 12, should be $\frac{3}{8}$-inch.

Piping O Q, being 3 feet 6 inches long, and supplying the (twelve) outlets 1 to 12 inclusive, should be 1-inch.

Piping 13 Q, being 23 feet 6 inches long, and supplying the (one) outlet 13, exceeds the maximum length of $\frac{3}{8}$-inch permitted to supply one outlet, and, therefore, the distance 13 P should be composed of 20 feet of $\frac{3}{8}$-inch, and the remaining distance P Q should be composed of 3 feet 6 inches of $\frac{1}{2}$-inch.

Piping Q R, being 5 feet long, and supplying the (thirteen) outlets 1 to 13 inclusive, should be 1-inch.

Piping 14 R, being 4 feet 6 inches long, and supplying the (one) outlet 14, should be $\frac{3}{8}$-inch.

Piping R S, being 3 feet long, and supplying the (fourteen) outlets 1 to 14 inclusive, should be 1-inch.

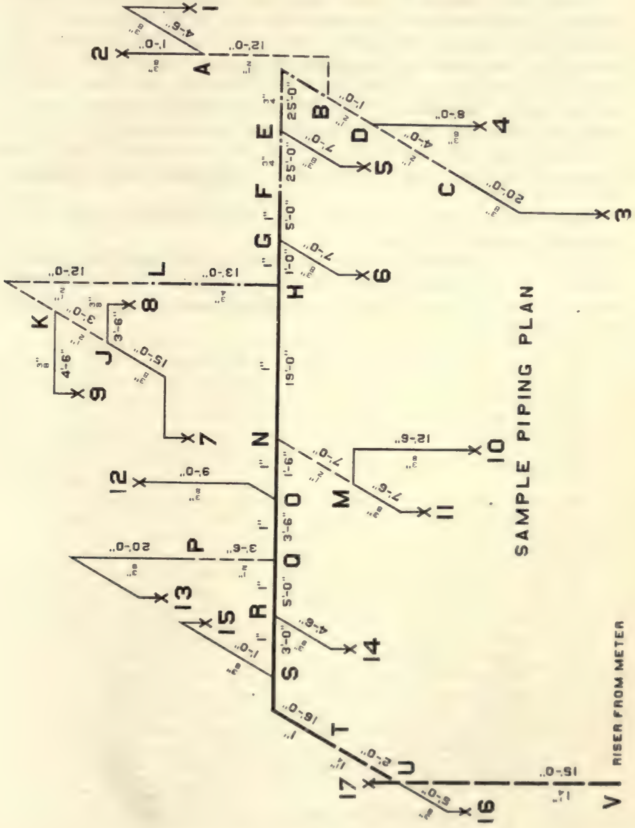


Figure 183.—Piping Plan, page 598.

Piping 15 S, being 1 foot long, and supplying the (one) outlet 15, should be $\frac{3}{8}$-inch.

Piping S U, being 18 feet long, and supplying the (fifteen) outlets 1 to 15 inclusive, exceeds the maximum length of 1-inch permitted to supply 15 outlets, and, therefore, the distance S U should be composed of two sizes of piping, 1-inch and $1\frac{1}{4}$-inch, and as 32 feet of 1-inch pipe have been already run from H to S, and a total of 44 feet of 1-inch is allowable to supply point H (nine outlets), the difference between these amounts, or 12 feet of 1-inch pipe, is only permitted to be run from S to T, the distance T to U, or 6 feet of the 18 feet required, being composed of $1\frac{1}{4}$-inch pipe.

Piping 16 U, being 5 feet long, and supplying the (one) outlet 16, should be $\frac{3}{8}$-inch.

Piping U V, being 15 feet long, and supplying the (sixteen) outlets 1 to 16 inclusive, and also the plugged 1-inch outlet 17, which counts as seven outlets, making a total of 23 outlets, should be $1\frac{1}{4}$-inch.

CHAPTER LIV

FIXTURE SPECIFICATIONS

New Fixtures

Definition

The term "new fixtures" as here used, designates fixtures that have never had gas through them.

Specifications

The specifications printed below are those adopted by the American Gas Institute in 1916.

SPECIFICATION FOR GAS FIXTURES

General

Gas fixtures should be of such mechanically good construction that proper installation, operation and maintenance will be assured without encountering any special difficulty.

Care should be exercised in the design of the fixture, so that no portion of it interferes with ready access to any nut or screw which may be necessary to get at for the purpose of adjustment.

Brass pipe or tubing should be either seamless drawn or brazed; in either case, of best quality to allow bending and threading without splitting.

The thickness of walls of brass pipe or tubing should be not less than No. 18 B. & S. gauge (0.04030 inch), except when it is used as casing or covering for iron pipe, in which case it should be not less than No. 22 B. & S. gauge (0.02534 inch). Both of these gauges are subject to the usual gauge tolerance of plus or minus 0.002 inch. Particular attention should be paid to having tubing which runs the full gauge.

> (Note. — While No. 18 gauge is very generally in use, it is believed that it is very much better to use No. 17 gauge. This is not because the 18-gauge tubing is not strong or rigid enough, but because when threads are cut on it, there is not sufficient metal to be sure that a good joint is made. If the 18-gauge always ran full size, or a little over size, there would be no objection to its being used, but as it is necessary to allow some variation in the gauge of tubing, it is thought that No. 17 gauge should be specified.)

Iron pipe should be of the American standard size.

1. Size of Threads

(*a*) All threads on brass tubing should be straight threads to conform to the standard specifications adopted by the American Society of Mechanical Engineers in 1915.

(*b*) All pipe threads for iron pipe should be the standard iron pipe size. (Briggs standard.)

(*c*) When brass tube and iron are connected, the thread should be gas-fixture size, brass tubing thread on both the brass and the iron, but it is recommended that, where possible, instead of connecting the parts in this manner, a brass bushing be used, threaded on the outside with a standard I. P. S. thread to screw into the iron body, the bushing being tapped on the inside with a straight gas-fixture size, brass tubing tap, for the connection of the brass tube.

2. Assembling Requirements

(*a*) Joints of the stems or arms at the body should be well threaded and depend on the thread for strength. All joints connecting tubing to cocks or nozzles should be threaded where possible, and brazed.

(*b*) The threaded portion of pendant body, or manifold, for fixture stem to be of such depth that in no case will the stem come in contact with the arms. The pendant body should be threaded for at least four full threads, both for the stem and arms.

(*c*) Fixture arms should not extend into the pendant body, or manifold, for a greater distance than the threaded portion of the manifold.

(*d*) If the arms of the pendant are straight, then the pendant body, or manifold, should be drilled in such a way that the arms will be perpendicular to the stem.

(*e*) The burner nozzle, or nipple, to have a $\frac{1}{8}$-inch iron pipe, male thread. The length of this threaded portion should be not less than $\frac{9}{32}$-inch and not more than $\frac{11}{32}$-inch, and the bottom of the thread should be recessed so that the burner will make a neat, tight joint, with the finished end of the arm immediately before the threaded portion.

(*f*) The axes of the burner nozzles should be vertical.

(*g*) Special precautions should be taken in the construction to prevent the obstruction of the gas-ways by foreign matter, such as gas fitters' cement, solder, or other jointing material, or metal chips. The ends of tubing should be reamed to remove burrs. When duplex tubing is used, care should be exercised to prevent faulty alignment of the gas-ways.

(*h*) Gas fitters' cement should not be used on any part of the fixture where it may be affected by the heat from the burners. When solder is used, it should be of such a mixture that it will not be affected by the heat from the burners.

(*i*) Fixtures for use out of doors, or in exposed situations, should be provided with suitable drips, or means for the convenient removal of condensation from any part of the fixture in which such condensation may accumulate. Independent pilot lines in outdoor fixtures should be not smaller than $\frac{1}{8}$-inch iron pipe size.

(*j*) Globe holders should be of such construction and weight that they will support properly, without sagging or bending, any globe or shade with which they are intended to be used. They should be readily and rigidly attached to the fixture arm or portable stand, and held in place by screwing down the burner, or by other means. They should provide a good seat for all parts of the globe with which they are supposed to be in contact. Eyelets should be inserted where screws are used for holding the globe, these eyelets to be of such a size that they will provide at least three full threads.

(*k*) When a fixture has two cocks at the body, the cocks should be so placed that the keys will, at all times, be at least 1 inch apart in the clear.

3. Goose or Stork Neck

(*a*) The thread on a fixed portion of a goose or stork neck should be not less than $\frac{9}{32}$-inch in length, and should be threaded with $\frac{1}{8}$-inch I. P. S. thread.

(*b*) The ground joint between the fixed and movable portions should have a bearing surface of not less than 1 inch, and the diameter of the small end of the ground joint should be not less than $\frac{3}{8}$-inch.

(*c*) The joint should be thoroughly and properly ground and not merely tool finished. It should be perfectly gas tight, without grease, under a pressure of 8 inches water column. The joint may be tested for satisfactory grinding by wiping the plug and body free from grease and putting on the plug a small quantity of dry red lead or chalk. The plug when turned in the body should then show neither high nor low places.

(*d*) It should be possible to lock the movable part to the fixed part by a bayonet lock, or approved means.

4. Casing

Where casing is used it should be cut to an exact length so that the joints may be made up tight, without marring or jamming the parts of the fixture at either end of the casing.

5. Chain Pulls

(*a*) Where a by-pass chain passes through a part of the casing or an ornament of the fixture, the opening through which the chain passes should have an eyelet, or similar means, to prevent the links of the chain from catching on the edges of the opening. If a rod is used in place of a chain, the eyelet may be omitted.

(*b*) If a chain pull is to be used, a sample of such chain should be submitted for examination and approval.

6. Cocks on Portable Stands

A portable stand should not have a cock as part of the stand.

7. Swing Joints

The committee desires to go on record as being opposed to the use of brackets having swing joints. It is felt that in practically all cases they are unnecessary, and they are without

doubt a source of much annoyance and expense, unless well constructed and properly installed and used. The use of swing joints is being noticeably lessened, but because there is still some demand for fixtures of this type, the following suggestions should be carefully followed:

(*a*) In fixtures having swing joints, the swing joint should be constructed in accordance with the specification for the gas fixture cock in so far as that specification may cover the plug, the gas-way and the lock nut and jamb nut. It is to be understood that in no case shall the diameter of the plug at the small end be less than $\frac{3}{8}$-inch. In no case shall the gasway around the plug be less than $\frac{1}{8}$-inch wide and $\frac{1}{16}$-inch deep.

(*b*) Fixtures having swing joints should be so made that the arms of the fixture will, at all times, be in parallel horizontal planes and the construction should be sufficiently heavy so that the arms will maintain substantially these positions when a lamp of any weight up to $2\frac{1}{4}$ pounds is attached. (The deflection with a weight of $2\frac{1}{4}$ pounds should be not over $\frac{1}{2}$-inch.) Exception: Fixtures which are intended to revolve in planes other than horizontal planes, need not conform with this clause of the specification, but should be submitted for examination and approval.

(*c*) Swing joints should be so assembled that the weight of the fixture has a tendency to seat the plug in the body.

8. Center Control Cocks

(*a*) A center control cock, which is the cock used for controlling the supply of gas to a fixture having two or more arms, and which may or may not be at the same time a by-pass cock, should have, in all cases, a $\frac{3}{16}$-inch gasway, and in other dimensions should conform with the gas fixture cock specification appended hereto.

(*b*) If this center control cock has lever arms, these arms should be of sufficient length to permit of easy operation of the cock so that neither the arms, nor the rods, nor the chains, operating the cock, come in contact with the body arms or other parts of the fixture.

9. Grease

The grease used on cocks, or swing joints, should not contain resin, rubber, paraffine or similar substance. When the cocks are exposed to heat, as in the case of a by-pass cock over an inverted incandescent lamp, the grease should be made of a good quality of gas engine cylinder oil and graphite, in proportions of about 1 pound of graphite to 1 pint of oil. This grease is also preferred for use with all cocks. Where this lubricant is not used, a satisfactory grease is one made of pure beeswax and a good quantity of tallow lard, in about the proportions of 3 parts of beeswax to $2\frac{1}{2}$ parts of tallow or lard. It is recommended that a small quantity of gas engine cylinder oil be added to make the grease thinner.

10. Sizes of Pipe or Tubing Used in Fixture Stems

	Maximum No. of Lights	When Made of Iron Pipe		When Made of Brass Tubing	When made of Brass Chain Gasway Down		Size of Gasway through Cock
		Cased	Un-Cased		Both Sides	Centre or One Side	
23″ and under......	1	$\frac{1}{8}$″	$\frac{1}{4}$″	$\frac{3}{8}$″	$\frac{1}{4}$″	$\frac{1}{4}$″	$\frac{1}{8}$″
33″ and under......	2	$\frac{1}{4}$″	$\frac{1}{4}$″	$\frac{3}{8}$″	$\frac{1}{4}$″	$\frac{3}{8}$″	$\frac{3}{16}$″
Over 33″ & under 42″	2	$\frac{1}{4}$″	$\frac{3}{8}$″	$\frac{1}{2}$″	$\frac{3}{8}$″	$\frac{3}{8}$″	$\frac{3}{16}$″
Over 42″ & under 72″	2	$\frac{3}{8}$″	$\frac{3}{8}$″	$\frac{1}{2}$″	$\frac{3}{8}$″	$\frac{3}{8}$″	$\frac{3}{16}$″
Any length to 42″...	4	$\frac{3}{8}$″	$\frac{3}{8}$″	$\frac{1}{2}$″	$\frac{3}{8}$″	$\frac{3}{8}$″	$\frac{3}{16}$″
Any length 42″–72″.	4	$\frac{3}{8}$″	$\frac{3}{8}$″	$\frac{1}{2}$″	$\frac{3}{8}$″	$\frac{3}{8}$″	$\frac{3}{16}$″
Any length 42″–72″.	7	$\frac{3}{8}$″	$\frac{1}{2}$″	$\frac{3}{4}$″	$\frac{3}{8}$″	$\frac{1}{2}$″	$\frac{1}{4}$″
Any length 42″–72″.	12	$\frac{1}{2}$″	$\frac{3}{4}$″	$\frac{3}{4}$″	$\frac{3}{8}$″	$\frac{1}{2}$″	$\frac{5}{16}$″
Any length 42″–72″.	20	$\frac{3}{4}$″	1″	1″	$\frac{1}{2}$″	$\frac{5}{8}$″	$\frac{1}{4}$″

Note. — When made of duplex tubing, the area of the main gasway should be equivalent to the area of the corresponding brass pipe size in the above table.

Fixtures not covered above, or having a drop of more than 6 feet, or having more than 20 lights, use size of piping according to the company's piping rules.

(*b*) "Length of Stem" is understood to be the distance in a straight line from the stiff joint to the lowest point of the pendant. In the case of wall brackets which carry more than one burner, the sizes given in the table are correct, except that no pipe smaller than $\frac{1}{4}$-inch should be used. In brackets which carry more than one burner, the "Length of Stem" is understood to be the distance from the stiff joint to the point where the arms diverge.

(*c*) Sizes of pipe or tubing to be used in one-piece or harp pendants:

Number of Lights not Exceeding	Harp (Maximum Size 18″ x 12″)		Stem (Maximum Length 36″)	
	Iron Pipe	Brass Tubing	Iron Pipe	Brass Tubing
1	$\frac{1}{8}$″	$\frac{3}{8}$″	$\frac{1}{4}$″	$\frac{1}{2}$″
3	$\frac{1}{4}$″	$\frac{1}{2}$″	$\frac{3}{8}$″	$\frac{1}{2}$″
5	$\frac{3}{8}$″	$\frac{1}{2}$″	$\frac{3}{8}$″	$\frac{3}{4}$″

11. Sizes of Piping or Tubing for Arms

(*a*) Arms of pendants, or of wall brackets, i. e., those parts which carry gas for only one burner, should be made not smaller than the following sizes:

Length of Arm	When Made of Iron Pipe		When Made of Brass Pipe
	Cased	Uncased	
12″ and under	$\frac{1}{8}$″	$\frac{1}{4}$″	$\frac{5}{16}$″
Over 12″ to and including 18″	$\frac{1}{4}$″	$\frac{1}{4}$″	$\frac{3}{8}$″
Over 18″ to and including 24″	$\frac{3}{8}$″	$\frac{3}{8}$″	$\frac{1}{2}$″
Over 24″	$\frac{3}{8}$″	$\frac{3}{8}$″	$\frac{5}{8}$″

NOTE. — When over 24 inches in length, the arms should be properly supported by some means other than their attachment to the wall outlet in case of a bracket, or the body in case of an arm.

(*b*) "Length of Arm" is understood to be a distance measured as follows:

In pendants—a straight line from the center of the stem to the center of the burner nozzle.

In stemless wall brackets, like stiff brackets, or single swing or double swing brackets, carrying but one burner—a straight line from the stiff joint to the center of the burner nozzle, measured when the bracket has its maximum reach.

In stemmed wall brackets—a straight line from the point of divergence of the arm to the center of the burner nozzle.

(*c*) In the case of cast wall brackets or cast arms, the area of the gasway in stems or arms should be not less than the area of the equivalent pipe, or tubing specified in Section 11, Par. (*a*)

12. COCKS

All cocks, including arm cocks, center-control cocks, lantern cocks, or any shut-off cock, should be made in accordance with the "Specification for Gas Fixture Cocks." By "shut-off cock" is meant any cock intended to be used for completely shutting off the gas supply to a burner or burners.

SPECIFICATION FOR GAS FIXTURE COCKS

It is not intended that this specification shall in any way govern the design of fixture cocks, except in so far as the dimensions given may govern the size. The accompanying drawing (Figure 184) which is on a large scale, is merely conventional, and is intended to show only the dimensions referred to in the specification.

(1) The material of both plug and body should be free from all defects, and of such grade that constant use will not cause excessive wear.

(2) The end of the plug should have two flat sides for the washer, and two nuts—a main nut and a jamb nut—should be used instead of a tail screw (Boston type). The plug and the male thread on the end of the plug should be made preferably of one piece; if made of two pieces, the nipple forming the male thread on the end of the plug should be screwed and sweated with hard solder into the plug.

(3) The bearing surface for the washer on the cock body should be not smaller in diameter than the diameter of the washer. The washer should wear evenly on the face of the body.

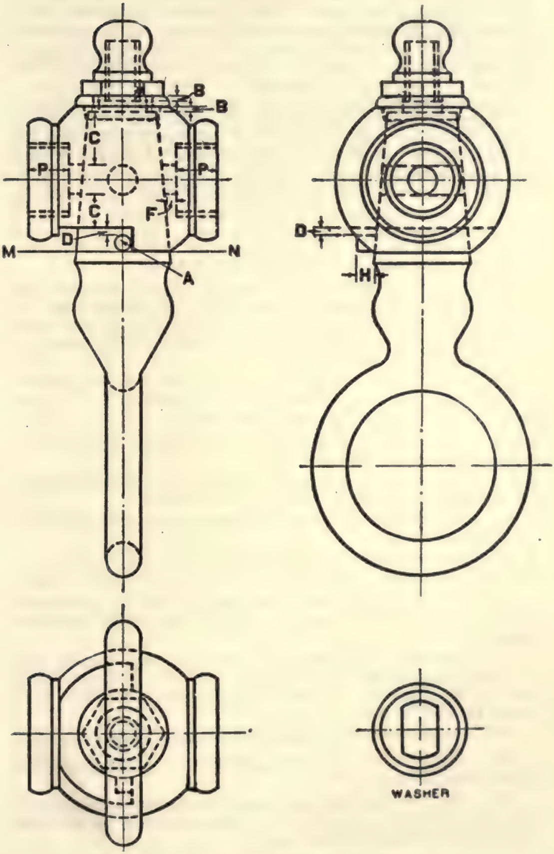


Figure 184.—Standard Philadelphia Fixture Cock, page 608.

(4) The plug should stop at 90° in either direction when shut off, but when the cock in question is a main by-pass cock, it may be a quarter-turn cock. The plug should be carefully tool-finished, and thoroughly and properly ground. It never should be left in the tool-finished state. The question of thorough grinding is of great importance; any sign of insufficient grinding will lead to the rejection of the cock. The cock should be perfectly gas tight, without an excess of grease, under a pressure of 8 inches of water column, while the plug may be turned by hand. The cock may be tested for satisfactory grinding by wiping the plug and body free from grease, and putting on the plug a small quantity of dry red lead, or chalk. The plug when turned in the body should then show neither high nor low places.

(5) For turned cocks, the thickness (F) of the body wall at the gasway should be not less than $\frac{3}{32}$-inch. For cast cocks, the thickness of the body wall at any point, including the part that forms the miter, should be not less than $\frac{3}{32}$-inch.

(6) The tapered hole through the body should be recessed at the small end to a diameter at least 0.003 inch larger than the diameter of the small end of the plug; this is done to prevent the formation by wear in grinding of a shoulder in the small end of the tapered hole in the body.

(7) The gasway through both the body and the plug should be not less than $\frac{1}{8}$-inch diameter. The gasway in the plug should register with the gasway in the body.

(8) Neither of the two distances (B) provided to take up for wear, should be less than $\frac{1}{32}$-inch.

(9) Neither of the two bearing surfaces (C) on either side of the gasway, should be less than $\frac{3}{16}$-inch in length.

(10) The distance (D) provided to take up for wear, should be not less than $\frac{1}{32}$-inch.

(11) The seal between the gasways in plug and body, when the key is hard over, should be not less than $\frac{3}{16}$-inch in length.

(12) The stop pin (A) should be either screwed or driven into place. If a driven pin is used, it should be made of soft annealed metal.

(13) Diameter of the stop pin: If a driven pin, not less than $\frac{1}{16}$-inch; if a screwed pin, not less than $\frac{3}{32}$-inch. No portion of any $\frac{1}{16}$-inch diameter pin should extend below the miter, i. e., below the line M N.

(14) Length (H) of the stop pin should be not less than $\frac{1}{16}$-inch.

(15) The key and the gasway should be straight on the axis of the body when gas is on.

(16) The key and the plug should be formed preferably of one piece of metal; if not, the two pieces should be attached firmly by sweating with hard solder.

(17) The cock body should have at the screw joint (P) not less than five full threads.

Old Fixtures

Definition

The term "old fixtures," as used here, designates fixtures that have had gas in them before.

General

In general, old fixtures equipped with cocks that will not turn all the way around, should be approved if they appear strong enough to support the burners with which they are equipped, have sufficient gasway to supply the necessary gas, and pass the regular third inspection pressure test.

CHAPTER LV

INSPECTIONS

Reasons For Inspection

New piping and fixtures should conform to the specifications already given. To insure this, and to make sure that the piping and fixtures are properly installed, the local company should reserve the right to take fixtures apart at any time, and to refuse to pass them if they are not constructed in accordance with good workmanship, and the following system of inspection should be established:

First Inspection

Test

The first inspection is principally one of sight, and, therefore, when the inspection is applied for, it is all important to have the piping in view. It consists of an examination, by the company's inspector, of the system of piping, after the installation has been completed and before it has been inclosed out of sight; and also a test of the piping while it is exposed, under a pressure of 3 pounds per square inch, or 6 inches of mercury column. The column should show no drop for a period of 10 minutes. To obtain this inspection, the fitter should:

Screw caps on every outlet, so that the inspector can make the pressure test. Omission of caps or use of cement to plug piping (either at the bottom of the riser or at any outlet) should be sufficient cause for the inspector to refuse to pass the inspection.

Test the piping with his own pump and gauge before requesting inspection.

Notify the local company.

Accompany this notice with a plan of piping, prepared as shown in Figure 182. Sheets of standard size for these drawings should be furnished by the local company, free of charge,

and the company should reserve the right to reject plans not submitted on these sheets. One plan should be accepted for an entire operation, providing the piping in each house is the same and there is not too long an interval between the completion of the first and last house.

When the piping is to remain exposed permanently, and is to be used for fuel purposes only, first inspection only should be required. If piping is exposed and is to be used for illuminating purposes only, or for fuel and illuminating purposes, and the applicant who installed the piping is also to install the fixtures, the first, second and third inspections may be combined in one inspection.

The first inspection may be omitted if the building, or a portion of the building, that is being piped is occupied. This omission is made in order to avoid undue inconvenience to the occupant; but where the fitter can arrange to leave all the piping exposed for a long enough period to permit of the first inspection, and at the same time not unduly inconvenience the occupant, he should do so. Buildings that are furnished but not occupied should not be accepted as occupied.

Caps should be allowed to remain on outlets until the fixtures are hung. The caps are necessary in order to protect the threads of outlets, and to prevent obstructions from entering the piping. Builders should insist on this practice being followed by fitters.

When a gas log or any kind of fireplace heater is to be installed, the supply line should be run to the point where the cock will be placed, before requesting first inspection.

Certificate

If the first inspection certificate is granted, the piping may be inclosed. After all danger of injury to the piping by the building construction is passed, the fitter should apply for the second inspection.

If the first inspection certificate is refused, the cause of the refusal should be explained to the applicant, and he be required to remedy the defects while the piping is still visible.

If the piping is approved, the following certificate should be given:

First Inspection Certificate

This is to certify that a preliminary inspection has been made of the piping at No.................................Street, for........................ outlets, before the piping was inclosed out of sight, and it was found to comply with our specifications.

As there is some danger that damage may be done to the piping during the various stages of construction, a request for second inspection should be made after the piping has been closed in.

....Company.

...............................191...........

Second Inspection

Test

The second inspection is principally one of pressure, and before it is applied for, all carpenter and other building work that might disturb the piping must be finished. It consists of a test, by the company's inspector, of the system of piping, under a pressure of 3 pounds per square inch, or 6 inches of mercury column. The column must show no drop for a period of 10 minutes. The second inspection is made after the piping has been inclosed, and is ready for the fixtures but before the fixtures are installed; it should not be made until after the final, or white, coat of plaster is on. To obtain this inspection, the fitter should:

Screw caps on every outlet, so that the inspector can make the pressure test. Omission of caps or use of cement to plug piping (either at the bottom of the riser or at any outlet) should be sufficient cause for the inspector to refuse to pass the inspection.

Test the piping with his own pump and gauge before requesting inspection.

Notify the local company.

Certificate

If the applicant, after obtaining the certificate of second inspection, installs the fixtures, he should apply for the third inspection.

If the second inspection certificate is refused, the cause of the refusal should be explained to the applicant, and he be required to remedy the defects.

If the piping is approved, the following certificate should be given:

Second Inspection Certificate

This is to certify that an inspection has been made of the piping at No.................................Street, for.................................. outlets, and it was found to comply with our specifications. As injury may occur to the piping subsequent to this inspection, its future soundness is not guaranteed.

....Company.

....................................191..........

Third Inspection

Test

The third inspection is principally one of fixtures, and being the final test, it should not be applied for until the piping and fixtures are ready to receive gas. It consists of a test, by the company's inspector, of a system of piping and fixtures, under a pressure of 6 inches of water column. The column should show no drop for a period of 10 minutes. This third inspection is made after the fixtures have been installed and the system is supposed to be ready for gas. To obtain this inspection, the fixture dealer or fitter should:

See that all outlets are supplied with fixtures. If any outlet is not to be supplied, notice to this effect should be given when requesting third inspection.

See that all fixture keys are adjusted so they may be turned by hand.

Screw all fixtures up tight before making test, and leave them tight after test is made.

See that fixtures are fully equipped with burners. All flat-flame burners should be of the union jet type.

On burners equipped for electric ignition, open all keys not controlled by electricity, and which, therefore, under normal conditions of working, remain open, the flow of gas being held back by the apparatus controlled by electricity.

Test the piping and fixtures with his own pump and gauge before requesting inspection.

Notify the local company.

Fixture dealers should test the piping, and, if necessary, have repairs made, to insure that the piping is tight before the fixtures are installed. Fixture dealers hang fixtures on leaky piping at their own risk.

As piping may be rejected for reasons other than tightness, it does not follow that because piping is found tight,

first inspection has been passed. Therefore, a certificate of third inspection should not be issued even if fixtures prove tight, until first inspection has been passed, and fixture dealers, before installing fixtures, are urged to ascertain whether first inspection has been passed.

Certificate

If the third inspection certificate is refused, the cause of the refusal should be explained to the applicant, and he be required to remedy the defects.

If the piping and fixtures are approved, the following certificate should be given:

Third Inspection Certificate

This is to certify that an inspection of the piping and fixtures at No. .... Street for .... burners, has been made and they have been found to comply with our specifications.

As injury may occur to the piping and fixtures subsequent to this inspection, their future soundness is not guaranteed.

....Company.

..............................191........

Office Routine

In the following outline, the routine recommended for a large company in the handling of this class of orders will be explained in much detail for the greater or less benefit to each reader in his own situation.

All requests for interior piping inspection should come to the distribution department directly from the plumbers or fixture dealers, or by way of the commercial department order desk, but the understanding should be that plumbers and fixture dealers should deal directly with the distribution department, as this saves time and trouble.

In the case of a first inspection, a plan of the piping, on a form similar to Figure 182, should be submitted when the request for the inspection is made.

All orders for interior piping inspection should be issued by the distribution department, on a form as shown in Figure 185. When a request for any inspection is made to the order desk of the commercial department, it should be forwarded to the distribution department on a memorandum form, with the plan and any letter or telephone message from the plumber or

fixture dealer attached, and the distribution department should issue whatever order the circumstances may call for.

ADDRESS			**HOUSEPIPE INSPECTION**
APARTMENT		FLOOR	
NAME		ADDRESS	
PLUMBER			
FIXTURE DEALER			
TENANT		BUILDING USED FOR	
SIZE OF SERVICE	SIZE OF RISER	NUMBER OF OUTLETS	NUMBER OF BURNERS
FIRST PASSED	DATE	THIRD PASSED	DATE
BY		BY	
CERTIFICATE ISSUED		CERTIFICATE ISSUED	

Figure 185.—Housepipe Inspection Card, page 616.

No report of the results of the inspections need be made to the commercial department, except when a third inspection is passed, or when a plan and request for a first inspection for a building operation or an apartment house is received by the distribution department. In the former case, the work order duplicate, with the "Work Completed" date stamp, serves as a notice, and in the latter case, on receipt of the plan, the memorandum should be filled in with the number of buildings or apartments and sent to the commercial department, to whom this information is useful in spacing accounts in new consumers' ledgers.

No second or third inspection order should be issued until the first inspection, or the first and second inspections respectively are passed. A separate order should be issued for each address, or separate system of piping, and for each inspection except when two inspections may be combined.

The checking of the plan as drawn on Figure 182 should be done by an office employe, or by the housepipe inspector, and at the time this plan is checked, each outlet should be numbered, if this has not already been done, beginning with the outlet furthest from the meter as #1. If the plan is complete but shows piping is not in accordance with the specifications, it

should be given to the housepipe inspector to determine, by a visit to the premises, if the piping was run according to the plan, and is, therefore, wrong; or if the piping was run in accordance with the schedule, and the plan is wrong. If the former condition is found, the plan should be returned, and the following letter sent to the plumber:

> Enclosed we return plan for piping for ....
> Changes indicated in plan at .... are necessary to make it in accordance with our "Specifications for Housepiping," and must be made before first inspection can be had.
>
> Do not make another plan, but make changes on plan enclosed, and return it to us as soon as possible.
>
> In order that the work of covering in the piping be not unnecessarily delayed, we ask that you have the necessary alterations made and the corrected plan returned to us within seven days, so that it will not be necessary for us to request the builder to delay his work pending our inspection.

Ordinarily, the inspector should not make a pressure test at this time, but in cases where there is a hurry to get the piping covered over, he could be empowered to make the test and pass such of the piping as is tight and of the proper size.

If at the time the inspector is checking a plan, he notices gas fitters' cement on the piping, he should report this fact, and the plumber should be notified that piping or fixtures so repaired must be replaced.

Should a plumber not ask for a re-inspection within seven days after the rejection of any work, it is sometimes advisable to write the following letter to the builder or owner of the premises concerned, enclosing a copy of the rejection letter sent to the plumber:

> Enclosed find copy of a letter sent .... days ago to.. Up to date we have had no word to proceed with another inspection, and, therefore, request you to avoid doing any work that would interfere with our inspection, which we are ready to make on notice from the gas fitter.

After a system of piping passes the first, second or third inspection, the proper certificate, as previously described, should be sent to the plumber or fixture dealer.

If the piping or fixture fails to pass inspection, the plumber or fixture dealer should be notified by letter, as follows:

On ...., our inspector called to make .... inspection at..., Street. The .... failed to pass this inspection because...

....

In order that the .... be not delayed, it is requested that the necessary corrective work be attended to as promptly as possible.

Please advise when the system is ready for another inspection.

If a set or a turn-on order is being held pending the passing of the inspection, a copy of the above letter to the plumber, with a printed notice as below, should be sent to the prospective consumer:

TO THE CONSUMER

The enclosed copy of letter written to your plumber explains the delay in supplying you with gas. As soon as he advises us that he has attended to the necessary work, we will make another inspection.

....Company.

All assistance possible should be given the applicant, who is presumably waiting for gas, in having the defect remedied by the plumber or fixture dealer at fault.

When a third inspection is rejected for a new building and a set order is being held, a copy of the letter to the plumber, and the notice "To the Consumer" should be sent to the old as well as the new address of the prospective consumer.

When a set or turn-on order is held, and third inspection cannot be completed because all of the fixtures have not been installed,an inspection may be made of those installed, irrespective of the number, if it is not known when the balance of the fixtures will be installed. In such cases, the Third Inspection Certificate should not be sent until all the fixtures have passed inspection.

When a set, turn-on or connect riser order is received and there is a record of an inspection being rejected, and no corrective work done subsequently, a letter similar to the following should be sent to the prospective consumer:

As explained by our inspector, who called to make examination preliminary to introducing gas, it will be impossible to proceed with the work, owing to the fact that..

....

In order that there may be no delay in installing gas, it is requested that the necessary work be attended to as promptly as possible.

Upon notification that the work has been done, another inspection will be made, and if conditions are found to be satisfactory, gas will be introduced without delay.

When under this condition gas is supplied to a consumer for fuel only, pending the repair by the plumber or fixture dealer, a letter as follows should be sent:

> As explained by our inspector, who called to make examination preliminary to introducing gas for fuel and illumination, it will be impossible to proceed with the work owing to the fact that
>
> . ...
>
> We will, however, supply you with gas for fuel only.
>
> In order that there may be no delay in installing gas for illumination, it is requested that the necessary work be attended to as promptly as possible.
>
> Upon notification that the work has been done, another inspection will be made, and if conditions are found to be satisfactory, gas will be supplied for illumination without delay.

In cases where the plumber submits a plan to the distribution department for approval, prior to leaving an order for first inspection, it should be checked in the usual manner and returned by letter, stating plan to be correct, or calling attention to changes that may be necessary.

As it is one of the duties of the linewalkers to report new buildings that are being erected, and which ordinarily would be piped but for which no plans or requests for inspection have been received, it is good practice for a letter to be sent by the distribution department to the plumber, as follows:

> We understand that you are installing gas piping at ....
>
> ....
>
> We desire to inform you that we should receive a plan of this piping, and it should be inspected as provided for in our specifications covering this class of work.

At the same time, the following letter should be sent to the builder, enclosing a copy of the letter sent to the plumber:

> We understand that gas piping is being installed in new buildings constructed by you at.. for which we have not yet received a plan of the piping.
>
> This company has been authorized to exercise supervision over the character of material used and work done by gas fitters in installing piping for gas; therefore, we desire to inform you that we should receive a plan of this piping, and that before it is covered it should be inspected, as provided for in our specifications covering this class of work.

In cases where inspection is delayed because of non-access to the premises, a letter should be sent to the plumber, fixture dealer or prospective consumer, as follows:

Our inspector called at..
for the purpose of...
....
He reports that he was unable to gain access.
Kindly notify us when it will be convenient for you to admit our inspector.

Where there is a violation of the specifications and the gas has been shut off, it should be left off until a third inspection is passed. If the gas is found on, and has been turned on by someone not in the company's employ to supply a new consumer or an extension of more than one burner to piping already supplied, and if the piping has not been tested, a workman should be sent to make a regular turn-on test. If the piping is of the proper size and passes this test, it might be well to do nothing further in the matter, but if it fails to pass this test, the case should be treated as a leak in piping, and if, in addition, the piping is not of proper size, some one in authority should pass on this condition. Another condition to be borne in mind is that of an unauthorized turn-on by a person not connected with the company. In such cases a letter, stating the position of the company, should be sent to the offender.

Turning On and Off Gas

The company should reserve the right to turn gas into any new piping; or into any old piping which has been blown out, or taken apart and put back, or repaired, or extended, or partially replaced with new pipe, or the fixtures removed, or re-hung, or new fixtures hung. Therefore, in all cases where the gas has been turned off at the meter to do any such work, the plumber should be required to ask the company for a turn-on.

When it is necessary to turn off the gas for the purpose of working on the pipes or fixtures, the cock at the meter in the cellar should be used, and not the cock at the curb. If the job cannot be completed in one day, the piping can be capped so that gas can be used for the night. The company should arrange to thus turn on the gas day after day while the work is in progress. Application should be made as early in the day as possible to ensure a supply before darkness.

The company should reserve the sole right to disconnect, remove, or re-set gas meters.

Builder's Coöperation

The first inspection requires that the company's inspector visit the building, after the piping is completed and before it is

closed in. Builders should be requested to coöperate with the company at this point. The company's inspection is a safeguard to the builder. Inspectors should be instructed to be particularly prompt on first inspection orders, so as to cause no delay in building operations, or to reduce any necessary delay to the shortest possible length.

Builders also may coöperate with the company by requiring the fitters to present the proper certificate of inspection before they pay the fitters for their work.

Location of Service

Provision should be made, especially where the walls are very thick, for the entrance of a gas service pipe through the foundation walls to new buildings. The preferable arrangement is to build in the wall a sleeve of iron, or terra cotta, pipe at the point where the service is designed to enter. In order that the sleeve should be right as to size and location, the company should be communicated with, so that a representative may be sent to examine the plans, furnish a suitable sleeve, if necessary, and superintend its placing. In this way, architects and builders will be saved the annoyance of having walls cut into, and will also confer a favor on the company. Architects should embody in future specifications a clause obligating the contractor to arrange with the company for the placing of a proper sleeve, as above explained.

Sundry Details

All pressure tests by the inspector should be made with the company's pump and gauge. (See Figure 63, page 193.)

Applicants for inspection need not be present during every inspection by the company's inspector, but they should be present as often as possible.

Applicants should be cautioned to be very careful before requesting inspection, to see that the work to be inspected and tested is complete, and is in every way in proper condition to permit the inspector to make his examination and test promptly and without doing extra work. Applicants should always test the work with their own pump and gauge immediately before applying for an inspection; they will thus be sure to avoid such things as omitted caps, unfinished runs of pipe, incomplete fixtures, etc. The presence of such things, indicating carelessness and making it evident that no preliminary test has been made should be sufficient cause to reject the work.

Instructions to Housepipe Inspector

Below are given certain Philadelphia rules for the guidance of the housepipe inspector. It is also essential that he should become thoroughly familiar with the specifications it is his duty to enforce.

Attitude Toward Applicants

Treat plumbers, gas fitters and fixture dealers with courtesy and consideration, and encourage a feeling of friendship toward the company. Point out deviations from the rules in a pleasant manner, and volunteer information when it will be of assistance. The fact that the rules are broken repeatedly should not change your attitude nor cause prejudice.

Keep engagements made for you, and when this is not possible, notify your office of the reason for the failure, for use in case of inquiry from the other party to the appointment.

If the work is not quite ready when you arrive at the premises, you should, on request, wait a few minutes if possible, or return later.

Correct Addresses

Always check up the address on the order and give the number whenever possible. If you cannot locate the house by number, you should locate it as so many houses from the nearest street, the corner house to count as the first house on the street it is facing.

Check Plan

In checking for size and length, make a comparison between the plan and the piping. If the plan is right and the piping wrong, locate the trouble on the former. If the plan is wrong and the piping right, correct the plan, or make a new one for filing in the office.

Notify Builder

If the piping is not in accordance with the rules, and is likely to be covered up before the applicant can be notified by the office of the rejection, caution the builder on the job not to cover the piping. Explain that it has been rejected, but do not criticize the work. Also notify the office so that they will be acquainted with the conditions if an inquiry is made.

Attaching Gauge: First Inspection

Attach the gauge to a side outlet, preferably on the first floor. Pump the air in at the place the gauge is attached, and watch the gauge during the process. After the test, cap the outlet, making the joint gas tight.

Length of Test

In order to save time, shorten the ten-minute tests required by the rules, to three minutes. Never give less than a full three-minute test; do not guess, but time the test by a watch. If there is any doubt about the quality of the work, continue the test for

ten minutes also. Whether the test is for three minutes or ten minutes, reject the work if the mercury shows any drop during the test. Test large systems of piping, as in schools or public buildings, for a time as much longer than ten minutes as you judge may be required.

Attaching Gauge: Third Inspection

Make third inspection pressure test with water gauge through burner nozzle, to avoid removing fixture or bracket.

Attach Tag

At each address, attach "passed" tag, or "rejected" tag, to an outlet or burner, in a prominent place.

Tags for Risers

On the first inspection, determine what *tags will be needed to designate the parts of the buildings the different risers supply and how they should be marked, so that the tags may be ready for use when the third inspection is made.

Bracket Lines

If you find piping with bracket lines, or side outlets run from above, do not reject it unless you have reason to believe that it will give trouble. However, advise that in future the lines be run up to the outlet.

Nature of Repair

The report for a rejected job should state clearly what is wrong so that the office can cover all the details in a letter to the owner. The report for work that has passed inspection need give no details other than those asked for on the printed form.

Count Burners on Third Inspection Rejection

On rejecting third inspection, count the burners. This information will enable the setting of the size meter adequate for the entire consumption, even though it will be used for fuel only until third inspection.

Meter Location

When asked, give proper location for meter, if you feel competent; otherwise, refer the matter to the proper person and say that another man will call to give this information.

Make No Concessions

You are not permitted to grant concessions, but must pass or reject work by strict adherence to the rules given for your guidance. In case you think such strict adherence would work

---

*An aluminum tag, $\frac{7}{8}$-inch wide, with a $\frac{1}{8}$-inch hole punched in each end, and with the symbols embossed in letters $\frac{1}{2}$-inch high, makes a very good tag for this class of work. A large amount of abbreviation is possible in standardizing these symbols, and the average length of the tags is not more than 3 inches. It should be attached to the riser with a copper wire.

a hardship on the applicant, you should mention the fact in your report.

Causes for Rejection

When, in making any inspection, you find any reason for rejection, you should not stop the inspection at this point, but complete it, in order that other defects, if any, may be discovered and included in your report.

Absence of 10 per cent of the burners should cause a rejection of third inspection, except where you know that incandescent burners are to be used.

Open-Flame Burners

Ordinarily, open-flame burners should be placed not nearer than 2 feet to the ceiling. When you think they are so close as to be dangerous, report accordingly, but an inspection need not be rejected for this cause, unless you think the conditions are extremely dangerous.

Third Inspection

In making the third inspection, the following routine should govern your actions. Where no specific number is mentioned, examine one or as many fixtures as in your judgment may be required.

(*a*) Examine for those requirements under "Specification for Gas Fixtures" that are possible of inspection without taking the fixture apart. Lantern or harp fixture cocks, i. e., those with the gasway passing through the tail screw, should comply with all the requirements of "Specification for Gas Fixture Cocks," except that they do not have to have a main nut or jamb nut. If not right, reject the inspection. If right, proceed as in (*b*).

(*b*) Caliper barrel. (See Figure 64, page 195.) If less than $\frac{7}{8}$-inch in diameter, reject the inspection. If $\frac{7}{8}$-inch or over, apply pressure test as in (*c*).

(*c*) Apply gauge to flat-flame burner or burner nozzle, to avoid removing any fixture or glassware. If test for tightness is not passed, reject the inspection (see (*d*). If passed, and the house is an old one or very large, or the house being a new one, it is not certain that every outlet is accounted for, raise the pressure to 6 inches of mercury column and watch gauge for three minutes to discover any uncapped outlets papered over or otherwise obstructed. If a perceptible drop is shown, be governed by the cause. If tight, and with pressure still on, try all fixture keys for ease in turning and for clearness. If any keys are so tight that they cannot be turned by the fingers, reject the inspection, except in winter with no heat in house, in which case you may use small pliers to turn keys.

(*d*) Whether the pressure test is passed or not, remove a plug from each type of cock in the house and examine it for the requirements under "Specification for Gas Fixture Cocks," paragraphs 5, 6, 7, 8 and 9.

(*e*) To test for grinding, wipe off excess grease from plug, sprinkle with a light coating of dry powdered red lead, and replace plug in cock barrel, firmly seating it and turning several times to the stops on both sides. If the lead forms into streaks, these indicate low points or grooves, and if extensive, the inspection should be rejected.

(*f*) To test for the recessing of the small end of the tapered hole through cock body, remove plug from barrel and try to insert in top of barrel, fitting the small end of the plug into the small end of the tapered hole in the cock body. If shoulder of plug can be inserted more than $\frac{1}{16}$-inch into the barrel, the cock is properly recessed; otherwise, report it to the office with the name of the fixture dealer.

(*g*) In measuring the distances "*B*" and "*D*," (see drawing of standard fixture cock, Figure 184) accept $\frac{1}{64}$-inch on 10 per cent of the cocks.

(*h*) In measuring the bearing surface "*C*," on either side of the gasway, a departure of $\frac{1}{64}$-inch from the requirements may be allowed, but a report of any such allowance should be made.

(*i*) In determining whether there is a proper seal, follow these directions: Caliper the cock plug at the center of the gasway. Its diameter should be equal to or greater than the figures listed in the table below under "Diameter of Plug," and "Size of Gasway." Otherwise, reject the inspection.

Size of Gasway	Diameter of Plug
$\frac{1}{8}''$	$\frac{3}{8}''$
$\frac{9}{64}''$	$\frac{13}{32}''$
$\frac{5}{32}''$	$\frac{27}{64}''$
$\frac{11}{64}''$	$\frac{7}{16}''$
$\frac{3}{16}''$	$\frac{15}{32}''$
$\frac{13}{64}''$	$\frac{31}{64}''$
$\frac{7}{32}''$	$\frac{33}{64}''$
$\frac{1}{4}''$	$\frac{35}{64}''$

Watch for New Buildings

If you notice any work requiring inspection for which you have not received an order, stop and advise the plumber to send in his order.

Operation Work

Keep in touch with operation work by frequent visits, and do not wait for a notice from the plumber for each house.

SECTION II

INSTALLATION AND MAINTENANCE

CHAPTER LVI

INSTALLATION

General

As was made clear in the opening paragraphs of Chapter LIII, gas companies usually do not install housepiping in buildings under construction. They confine their housepiping jobs to occupied buildings, principally dwellings, where one of the inducements to the use of gas is a low first cost of piping, fixtures and burners. (The special supply lines that may be required for domestic cooking, for water heating or for industrial purposes, are not considered as housepiping.) Therefore, there is no need in this manual to give all the information that might be required in a book on housepiping, of which there are several adequate treatises available. The specifications already given prescribe certain materials and methods of working, and in this chapter are added additional details relating, except where otherwise noted, to the installation of piping in old buildings of various types.

Factories

Before the piping plan can be made, the style and location of the illuminating units must be determined. In large factories, as in large buildings of any kind, this is a job for a competent illuminating engineer. He would furnish a lighting layout, as illustrated in Figure 186. From this, after a study of the building construction, the location of the necessary piping would be fixed and a working piping plan drawn, as shown in Figure 187. With both plans as guides, a good workman could make the installation without much additional instruction. Certain

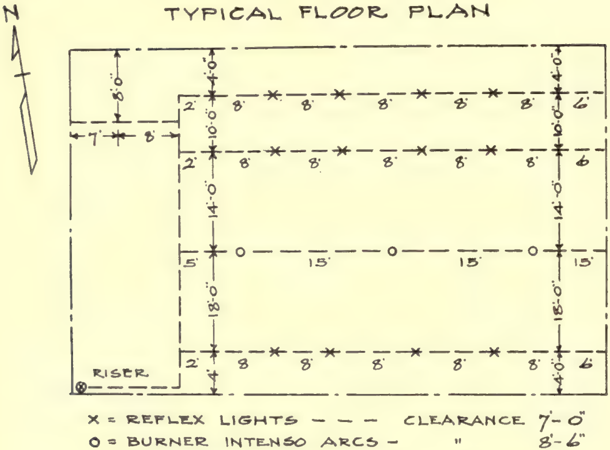


Figure 186.—Lighting Layout, page 627.

details would be determined by local conditions. In small factories there probably would be no building service (see page 592), but each riser would be carried to a common point in the basement, as called for by the housepiping specifications. Under these circumstances, the consumer, rather than the floor, would be the unit, and there would be one riser for each consumer. On the other hand, where there is a building service, there usually would be a meter for each floor, because in this class of buildings each floor is occupied by one tenant only. Where the sole or the best supports for horizontal piping are the bottom members of a roof truss, the layout should be planned with the pipe at right angles to the trusses, so that the lights, whether situated along the lines of the trusses or between them, may be suspended from the piping without any additional support. If a last outlet occurs between two trusses, the choice is to extend the piping to the next truss or to suspend the outlet from the roof.

Churches

In a church exposed piping should be a last resort. The riser generally may be placed in a partition near the front

Housepiping Material

Name and Size		Quantity For 2 Outlets	For 4 Outlets	For 6 Outlets	For 8 Outlets	For 10 Outlets	For 15 Outlets
BUSHINGS:	$1'' \times \frac{3}{4}''$	1	1	1	1	1	1
	$\frac{3}{4}'' \times \frac{1}{2}''$	1	1	1	1	1	1
	$\frac{1}{2}'' \times \frac{3}{8}''$	1	1	1	1	1	1
	$1'' \times \frac{1}{2}''$	—	—	1	1	1	1
	$1'' \times \frac{3}{8}''$	—	—	1	1	1	1
	$\frac{3}{4}'' \times \frac{3}{8}''$	1	1	1	1	1	1
CAPS:	$\frac{3}{4}''$	—	—	1	2	2	2
	$\frac{1}{2}''$	—	—	1	2	2	2
	$\frac{3}{8}''$	3	5	8	10	12	15
COUPLINGS:	$\frac{3}{4}''$	1	2	2	3	3	4
	$\frac{1}{2}''$	1	2	1	2	2	3
	$\frac{3}{8}''$	1	2	3	4	4	5
ELLS:	$1''$	—	—	—	—	4	8
	$\frac{3}{4}''$	2	3	4	6	8	10
	$\frac{1}{2}''$	2	3	3	4	4	5
	$\frac{3}{8}''$	5	10	12	16	18	22
	$\frac{3}{4}'' \times \frac{1}{2}''$	1	1	1	2	2	3
	$\frac{1}{2}'' \times \frac{3}{8}''$	1	1	1	2	2	3
DROP ELLS—MALE:	$\frac{3}{8}''$	2	4	6	5	6	10
FEMALE:	$\frac{3}{8}''$	2	4	6	5	6	10
45° ELLS:	$1''$	—	—	—	—	2	2
	$\frac{3}{4}''$	2	2	2	2	—	—
SERVICE ELLS:	$1''$	—	—	—	—	2	4
	$\frac{3}{4}''$	2	2	2	3	3	3
	$\frac{1}{2}''$	1	2	1	2	2	2
	$\frac{3}{8}''$	2	4	4	6	6	6
NIPPLES:							
	$1''$ Close to $8''$	—	—	—	—	1 ea.	1 ea.
	$\frac{3}{4}''$ " " $8''$	1 ea.	1 ea.	2 ea.	2 ea.	2 "	2 "
	$\frac{3}{4}''$ $9''$ " $16''$	—	1 "	1 "	1 "	1 "	1 "
	$\frac{1}{2}''$ Close " $12''$	1 "	1 "	1 "	1 "	1 "	1 "
	$\frac{3}{8}''$ " " $12''$	2 "	3 "	4 "	4 "	4 "	6 "
PIPE:	$1''$	—	—	—	—	40 ft.	60 ft.
	$\frac{3}{4}''$	20 ft.	40 ft.	40 ft.	40 ft.	60 "	80 "
	$\frac{1}{2}''$	20 "	40 "	40 "	60 "	60 "	80 "
	$\frac{3}{8}''$	20 "	60 "	60 "	120 "	140 "	200 "
PLUGS:	$1''$	—	—	—	—	1	2
	$\frac{3}{4}''$	1	1	2	3	3	3
	$\frac{1}{2}''$	—	1	2	3	3	3
	$\frac{3}{8}''$	—	1	2	4	4	6

Housepiping Material—Continued.

Name and Size		Quantity For 2 Outlets	For 4 Outlets	For 6 Outlets	For 8 Outlets	For 10 Outlets	For 15 Outlets
EXTENSION PCS.	3/8"	2	2	3	4	6	8
HOOKS:	1"	—	—	—	—	6	12
	3/4"	4	6	8	8	8	12
	1/2"	3	6	8	8	8	10
	3/8"	6	10	12	12	12	16
FINISHING NAILS		12	18	25	30	36	40
8d WIRE NAILS		12	14	16	20	24	30
PLASTER		2 qts.	4 qts.	6 qts.	8 qts.	10 qts.	12 qts.
SCREWS, F. H.	1" x #10	10	12	30	30	30	40
LONG SCREWS:	1"	—	1	1	1	1	1
	3/4"	1	1	1	1	1	1
	1/2"	—	1	1	1	1	1
	3/8"	—	1	1	1	1	1
STRAPS:	3/4"	2	2	3	5	5	6
	1/2"	3	4	5	5	5	6
	3/8"	6	6	10	10	10	12
TEES:	1"	—	—	—	1	1	3
	1" x 1" x 3/4"	1	1	1	1	1	1
	1" x 3/4" x 1"	—	—	—	—	1	2
	1" x 3/4" x 3/8"	—	—	—	—	1	2
	1" x 3/8" x 1"	—	—	—	—	1	3
	1" x 3/4" x 3/4"	—	—	—	—	1	2
	1" x 3/4" x 1/2"	—	—	—	—	1	2
	3/4"	1	2	2	3	3	4
	3/4" x 3/4" x 1/2"	—	1	2	3	3	4
	3/4" x 3/4" x 3/8"	—	—	3	5	5	6
	3/4" x 3/4" x 3/8"	—	—	3	5	5	6
	3/4" x 1/2" x 3/8"	1	1	2	3	3	4
	3/4" x 3/8" x 1/2"	—	—	2	3	3	3
	3/4" x 1/2" x 3/4"	—	—	1	2	2	2
	3/4" x 3/8" x 3/4"	1	1	1	2	2	2
	1/2" x 1/2" x 3/4"	—	—	1	2	2	2
	1/2" x 3/8" x 3/4"	—	—	1	2	2	2
	1/2" x 1/2" x 3/8"	1	1	2	4	4	4
	1/2" x 3/8" x 1/2"	—	—	1	2	2	2
	1/2" x 3/8" x 3/8"	1	1	4	4	4	4
	3/8" x 3/8" x 1/2"	1	1	1	1	1	1
	3/8" x 3/8" x 3/4"	—	—	—	1	1	1

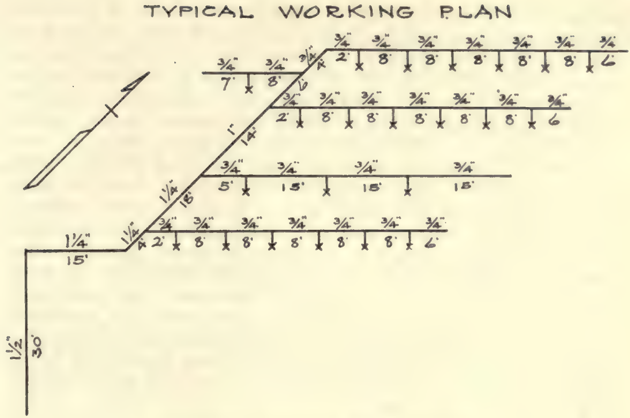


Figure 187.—Working Plan, page 627.

entrance. In this way it reaches the top of a side wall along which it is extended, branches being taken off as needed. With an exposed truss roof, characteristic of so many churches, each bottom member is available both to conceal and to support the pipe. If there is no truss available, the pipe might have to come down the wall, but even so, usually it will be so high that it will not be noticeable after it is painted to match its background.

Meeting Halls

Meeting halls resemble factory floors as to shape and churches as to use. They ordinarily require general illumination only, and their piping usually would be concealed. With paneled metal ceilings, an attempt should be made to locate each outlet in a panel center.

Stores

The average store into which gas piping is introduced after the erection of the building, is of such a character that exposed piping properly painted is not a great objection, while the saving in expense is often quite desirable. Upper floor conditions that would make concealed piping costly include carpeted rooms,

hardwood or diagonal flooring, and heavy pieces of furniture, In most cases general illumination only is required. If the space is long and narrow, one line of center outlets, with extensions and drops to side outlets, will be sufficient. For greater widths, two ceiling lines will be run, usually one over each counter, with the outlets staggered and with necessary extensions for side outlets.

In Philadelphia, there are many instances where a store occupies the lower floor of a two-story building which is given a single system of piping, on the assumption that the storekeeper will live on the upper floor. Sooner or later, many of these buildings contain two or more tenants, each of whom desires a separate supply. Where each tenant has an entire floor, a separation of the existing piping often may be made. If this is not feasible, as is generally the case when one tenant occupies the front room of the first floor only, the remedy is to run a separate line for the store and to remove the drops and plug the outlets of the original system where duplicated by the new system, in order to prevent any chance of one consumer using gas paid for by another.

Dwellings

Material Required

The orders for dwelling piping often are given in terms of the outlets required. Without further information, material may be delivered by use of the table on pages 629 and 630.

Details of Work

In dwellings, concealed piping is the almost invariable rule. The workman first determines the partition most suitable for the riser, being guided in this by the housepiping specification requirements for meter location. Then the outlets are located, and with a search bit the ceiling outlets may be marked on the upper floors. After this the general layout of the piping may be planned, and the endeavor should be to run as much pipe as possible at right angles to the floor joists, in order to minimize the removal of floor boards and to permit the use of long lengths of piping. For runs parallel to joists, and, therefore, at right angles to floor boards, trap holes must be cut in the latter, and their size and frequency determine the maximum length of the pipe to be inserted. The competent workman can lift the various boards in such a manner that after their replacement, it is hard to tell that they have been disturbed.

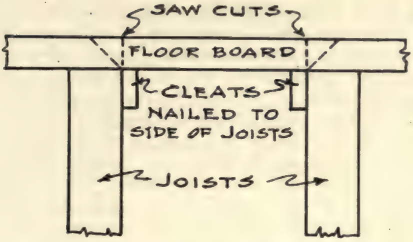


Figure 188.—Cleats for supporting Floor Boards, page 633.

Where sawing is necessary, a small starting hole and a thin compass saw are called for. Ordinarily, the saw cut must be vertical and flush with the edge of the joist. In this case, cleats, as shown in Figure 188, will be required to support the boards on replacement. If space permits, the sawing should be at a 45° angle with the floor and the cut flush with the edge of the joist, as shown by the dashed line in Figure 188. This will avoid any necessity for cleats and, with a very competent workman, results in a neater job than a vertical cut.

After sawing, a floor chisel (A, Figure 62, page 192) should be inserted, with its edge pointing toward the groove side of the board to be removed, until it catches the lower side of the lip. Then, by prying down on the chisel handle and at the same time hammering lightly on the adjacent board, the tongue of the latter will press against and split off the lower edge of the groove of the first board, which then may be easily removed.

When the necessary floor openings have been made, the exact piping layout and sizes are determined.

If concealed, and not exposed, pipe is desired to supply outlets located on walls not partitions, it is necessary to cut a slot.

Piping that is exposed should, of course, be installed in the least conspicuous place. The riser may be brought through a closet or behind a door, and other lines located in the angle between ceiling and wall. The extensions to the outlets are bound to be more or less conspicuous, but with suitable painting should be not unsightly. It is important to fasten securely the ceiling outlets which may carry fixtures.

All piping work in occupied dwellings involves, under the best conditions, a considerable annoyance to the occupants. The lifting and replacing of floorboards has been already mentioned. In addition, there may be the cutting of plaster, taking up of carpets, moving of furniture, and painting of piping. For all this the most careful and skillful workmen should be employed, so that every job will result in a satisfied consumer. As a rule, the work should be tested as installed, so that any fault can be readily repaired.

CHAPTER LVII

MAINTENANCE

Organization for Work

The maintenance of housepiping and fixtures consists chiefly in caring for complaints of leaks or insufficient supply. The workmen are usually known as complaint men or fitters, to distinguish them from the meter fitters or the appliance fitters, though even in the larger companies there are many employees who do all three classes of work. In this chapter, "complaint work" will be used to designate complaints referring to housepiping and fixtures and also to the meter and its inlet piping extending to the head of the service. The general organization of the entire fitting force is given in Chapter II, and details of the organization for meter fitting and for appliance work in Chapters XLIX and LVIII, respectively. The remarks in the latter chapter on the foremen and on the general characteristics of the men themselves, apply equally well to complaint men. The tool kits often carried by complaint men are shown in Figures 65 (page 196) and 66 (page 198). Their means of transportation are normally bicycles or motorcycles, as described on page 204.

One of the essential features of an efficient organization for complaint work is adequate arrangements for prompt service as required by day or by night.

Installations to demonstrate the conditions encountered in complaint work, with especial reference to the various kinds of obstructions producing insufficient supply, should form part of every shop equipment.

Work Completion Schedule

The reasons for a work completion schedule, the considerations affecting its details, and the routine for enforcing it, are described in Chapter LIX. Such a schedule is perhaps more necessary for appliance and meter work than for complaint work, because the latter is usually considered emergency work and is not apt to be

neglected even if its completion is not required within a set time. Nevertheless, as will be seen, there are several gradations of complaint work in point of urgency, and a completion schedule which recognizes these promotes efficiency and economy.

The schedule as used in Philadelphia is given below:

Nature of Complaint	Time to Complete (In days)
Leaks (*a*)	0*
Illumination (*b*)	0*
Meter and Housepiping (*c*)	1
Miscellaneous (*c*)	1

(*a*) If the order states, or indicates, that the leak is bad, it should be attended to as *quickly as possible* † and given precedence over all other orders not of equal importance.

(*b*) If the order states, or indicates, that the consumer is entirely without light, it should be attended to as *quickly as possible* † and given precedence over all others not of equal importance. Orders issued from mail matter should be classed as "zero" orders, unless the mail indicates that the consumer is not inconvenienced.

(*c*) If the order does not fall into the "Immediate Attention" class, but indicates from the mail attached that the consumer is inconvenienced, it should be attended to on the day of receipt.

* Zero means completion of order on day of receipt.

† These order cards should be stamped "Immediate Attention."

The schedule, of necessity, is drawn up in general terms, and applies to all orders for which the consumer has not requested a specific time of call. When the complaint desk is in touch with the consumer, either in person or by telephone, it often is possible to get very exact information, and the specific conditions may show that what would be normally a "one day" order, belongs to the "zero" class. The consumer may request what under the circumstances is unnecessary speed of completion. As a rule, unreasonable requests of this kind should not be granted. On the other hand, leak orders should be completed within the required time, unless the consumer requests delay and it is very certain that the leak is quite slight. Any promised date is, of course, shown on the order card. No leak order, though seemingly a duplicate of a previous order, should be treated as such unless the fact of such duplication can be established beyond doubt, as, for instance, by reaching the consumer on the telephone.

Dispatching Orders

In general, the efficiency of the complaint work service is dependent, to a great extent, upon the care and intelligence exercised by the man receiving the order, and the promptness with which it is transmitted to the shop and thence to the workman. In receiving a leak complaint across the desk or over the telephone, enough questions should be asked to determine the extent and supposed location of the escape, which should be designated as "in street," "in cellar," "at meter," "at fixture in room," "in fuel piping," "at range burner," etc. If the leak is considered dangerous, or is very noticeable, this fact should be noted on the order, which should be telephoned immediately to the shop. Questioning will sometimes develop the fact that there is no odor of gas and a leak is suspected owing to the size of the bill.

If the orders contain the proper information, the dispatching clerk at the shop is able to give preference to those of an urgent nature. A bad leak would be attended to before a slight one, and an order implying no gas supply throughout an entire building before one indicating a partial supply. As between a slight leak and an insufficient supply to a hospital, asylum, factory, etc., the latter order should take precedence.

When a number of similar complaints are received almost simultaneously from the same territory, one common cause should be looked for, and by bearing this fact in mind, useless trips often will be saved, consumers quickly told what the trouble is, and the latter sooner remedied. Widespread complaints of leaks are almost invariably due to odors coming from sewers or from oil refineries. Reports of insufficient supply, especially at dusk, are generally due to lack of pressure in certain mains, occasionally through the partial or entire closing of a main by an accumulation of condensation. The same reports during daylight indicate a sudden rush of water into a main, or its breaking, often through undermining or blasting. By the intelligent use of the telephone, the approximate limits of the supply failure may be sometimes obtained and thus the exact point of trouble more quickly located where surface indications are lacking.

Leaks

General Investigation

In Chapter XXXI, treating of street leaks, the procedure is taken up at the point where the workman decides that the gas is

coming from the street. Now we will describe what is done prior to that time. We will first consider the case of a locked house and no sign of inmates. Unless the order shows specifically that the leak is an inside one, the workman should remove any stop-box cover and note whether there is an odor there. He should also make an examination at the house wall where the service enters, and at the cellar windows. An odor at the stop-box or at the wall would be considered a street leak. With no odor at the windows, the name on the order should be verified by inquiry of the neighbors, and if so verified, an attempt made to ascertain when the occupant will return. If it is possible to gain admittance by going a short distance for some one, this should be done. If there is an odor coming from the building, any curb stop on the service should be closed, and it should be considered whether or not a policeman should be asked to force an entrance and thus permit an examination of the building in order to prevent the asphyxiation of any possible inmate (see page 337). This is one of the many cases where good judgment is required in connection with leak orders, but in this particular instance, the workman may usually communicate with the "shop man" (see page 331) and be told what to do.

If the house is open, as is usually the case, the workman may detect a strong odor coming from the cellar. If so, any curb stop should be closed, on the chance that the leak may be in the service pipe between the stop and the wall. The cellar should be ventilated by opening any windows from the outside, and with a bad leak, breaking the glass is preferable to entering the cellar in order to open windows. Unless to save others, the workman should not go alone into any cellar where there is a strong smell. Instead, another workman should be summoned, and while one man stands at the head of the stairs, the other should go down and, as far as possible, stay within sight. An occupant should be at hand to be called on by the man at the stairs if he finds he must go into the cellar to assist the first man. The respirator (Figure 56, page 181) should be used in extreme cases.

If the leak seems to be coming through the street wall, this information should be telephoned to the shop man. Pending the arrival of a street gang, the house should be ventilated as much as conditions seem to demand, and openings affording entrance for gas, stopped up with any available material. If for any reason it seems possible that the gas is coming in from one or more adjoining houses, their cellars should be examined.

Occasionally gas seems to be coming *into* a building through doors or windows, and then good judgment must be relied on to decide what closing, if any, is advisable.

The leak may be somewhere in the house above the cellar and yet not traceable to any exposed source. This is what is often called a "concealed" leak. Before deciding that such is the case, the workman should examine carefully all fixtures, appliances and exposed piping, as the annoyance and expense often incurred in cutting into walls or floors to look for a concealed leak make it imperative that there be no mistake in the diagnosis. When a concealed leak is very large, this fact is usually apparent from the existing odor. The meter furnishes the best of all means to determine the rate of leakage, and should be used for this purpose, especially as an aid to deciding whether the gas supply need be shut off pending repair. This applies to exposed leaks as well. The movement of the meter can be readily converted into cubic feet per hour, and from this a decision reached. The cases calling for the most careful consideration are those where there is an odor in sleeping rooms and no repair can be effected until the next day. A slight leak in the piping or fixtures of a large building containing no sleeping rooms, if expensive to locate or repair, might be very properly left unremedied with the knowledge and consent of the occupants.

When the meter shows no movement, it should be given "Test A" (see page 503), and if no movement is shown after this test has been passed, it is an indication that the leakage is from the house adjoining on the side where the odor is strongest.

When the leakage is so large that the gas must be shut off and may not be turned on again until a repair has been made, the location of the escape must be determined by the use of ether, peppermint, or some similar substance.

The workman answering a leak complaint should never report "no leak" unless he is absolutely certain. In all cases of doubt, an opportunity should be given for a second man to make an examination.

Specific Locations

Cellar Piping

So far we have considered only those cases where it has not been possible to locate the leak in some definite spot exposed to view. Now we shall take up exposed leaks, and begin in the cellar with the piping between the street wall and the meter.

Especially in a damp cellar, the service may rust through at the point of entrance. A permanent repair will require the removal of part or all of the service. A temporary repair here, or at any point on exposed piping, often may be made by applying soap, either with or without a tightly wrapped and tied covering of tallowed muslin. A permanent repair will require a new piece of pipe and a long screw. A leak at a fitting, if due to a split, requires a new fitting, but if a sandhole, sometimes may be patched successfully.

A leaking meter cock sometimes needs only tightening or greasing, but if it is badly worn or strained, a new cock is required.

Meter

Leaks in meter cases, as affected by meter design and by meter connections, are spoken of on pages 422 and 461, respectively. Notwithstanding all that has been done in this regard, the meter and its surroundings are still a prolific source of leaks, not only gas, but also condensation and, from dripping meters, oil. Gas or oil leaks at any soldered seam, provided the opening is not over $\frac{1}{2}$-inch long, and gas leaks at any putty joints of dial or index glasses may be repaired without removing the meter. The surface should be wiped off carefully and common brown soap applied by the fingers. After the leak has been stopped, a coating of japan or shellac should be placed over the soap and adjacent meter surface. This, by excluding air, prevents the soap from hardening. Only one seam patch should be allowed on a meter. By the above repairs many meter changes may be avoided. A leak at either coupling, if not remedied by a slight tightening, will usually stop with a new washer. It is a mistake to use much force on the coupling, as the new washer will, in the long run, prove cheaper.

Housepiping

Piping above the cellar usually is concealed, and access to it will be governed by the principle laid down in describing piping installation in occupied houses. The actual repair of leaks in piping or fittings is the same as for cellar piping. No patching of concealed piping is ever permissible.

Fixtures

Leaks in the brass or iron piping, or at a sweated-in joint, require removal to a shop and generally new material. Leaks at threaded joints usually may be repaired on the spot by tightening,

rethreading, or the use of new material. Leaks at keys generally stop after regreasing or tightening. Sometimes regrinding is required. A strained or badly worn cock requires replacing. If a key leak that is not very slight is not to be repaired promptly, the fixture should be removed and the outlet capped pending such repair, or the key should be so tightened that it cannot be turned by hand, and the consumer told to leave it alone. With a dangerous leak in any other part of a fixture not capable of immediate temporary or permanent repair, the occupant should be given the choice between the removal of the fixture and the shutting off of the entire gas supply.

Burners and Tubing

Leaks at flat-flame burners are stopped by releading, screwing the burner tighter, or supplying a new one. Leaky tubing should be replaced by new, but consumers of the poorer class often object very strongly to the destruction of tubing which, in their opinion, is not leaking sufficiently to be dangerous. This is, once more, a case where good judgment is needed to decide when to insist upon either the destruction of the defective tubing or the cessation of gas supply.

Policy Controlling Repairs

It is greatly to the interest of every gas company that the use of its product be accompanied by the minimum of annoyance. Potential sources of such annoyance are leaky housepiping and fixtures. Piping and fixtures installed under proper specifications will give little trouble under normal conditions of use, but poorly made fixtures and piping exceptionally exposed to corrosion or other injury result in numerous leaks. Every company should decide how much expense it is willing to undergo in remedying these leaks, all of which are beyond the meter outlet, and, therefore, no part of the cost of their repair is obligatory on the company. It is necessary also, especially where there may be not efficient control over installation work, to differentiate sharply between leaks in old material and leaks due to faulty work recently done. The only effect of a generous policy toward such new work would be to encourage inferior installations.

Three hours of labor of two men and the supply of a small amount of inexpensive material, such as pipe, should perhaps be considered as a reasonable limit of free work. If there seems to be a chance that the limit may be exceeded, the occupant should be told of this fact before the work is started, and that if the

allotted time does not suffice to effect a repair, he will be expected to employ a gas fitter, and, pending repair, the supply will be shut off if this course seems required by safety consideration. Such possible necessity for gas shut off, often against the wish of the occupant, arises fairly often, and has been spoken of in describing leaks at certain specific locations. It is sometimes brought about by the refusal of the occupant to release the company from responsibility for any damage generally due to necessary interference with woodwork and plaster. As was said before, every case must be decided by the best judgment available at the time. A written notice of the reason for such shut off and of the danger of resuming gas supply until a repair has been made, should be given. A written notice also should be sent, advising permanent repair where temporary repair only has been made by the company and permanent repair involves the employment of an outside gas fitter.

Leaks Affecting Bills

One of the consequences of the average consumer's inability to conceive of gas as a definite substance, and of his general ignorance of how a gas meter functions, is his usual misunderstanding of the effects of leaks on the gas bill. Not only does he believe that every leak he smells is of measured gas, and forms a mental image of its volume a hundredfold and more too great, but often, with equal disregard of physical conditions, infers a leak from the mere size of the bill. It is one of the obligations of the supplying company to enlighten him on all these points as far as may be possible.

To determine whether leaks actually found are of measured gas, the workman should be furnished with a list of standard phrases descriptive of the distributing system from the head of the service to the burner. The effect of leaks from the meter case is given on page 434. Even if the consumer is given the benefit of any doubt about such case leaks, these and leaks from outlet piping installed by the company are the only ones of measured gas for which the company could be in any way responsible and for which, therefore, allowance might be made.

This brings us to the second point: the exaggerated idea usually existing in the consumer's mind of the size of a leak as affecting his bill in dollars and cents. If the person who believes that a leak, which has not been especially noticeable in the days or even weeks before it is reported, has increased his bill by

several dollars a month, can be made to picture the volume in gas represented by this value, and shown, by a practical demonstration, the amount of odor created by an escape of only one-tenth of a cubic foot per hour, there is apt to be one less believer in corporate dishonesty.

Still more forcibly does the above argument of the impossibility of an appreciable escape of gas without a decided odor apply to the man who is sure he did not use the gas charged, which, therefore, in his opinion, must have leaked somewhere, if his meter on test proves correct.

Insufficient Supply

General Investigation

In discussing the importance of a gas company's being able to control the installation of housepiping, it was stated that consumers frequently suffered from insufficient supply without knowing it. These are usually cases where the diminution in supply has been quite gradual, often from a slowly increasing stoppage, and more rarely, as applied to a section of the distribution system, from increasing demand with no corresponding enlargement of the mains. This latter condition would hardly occur with any company which obtained the pressure records recommended in Chapter XXXIV.

Any sudden evidence of insufficient supply usually means a notice to the gas company, and on page 637 two reasons, both relating to mains, were given for the receipt of many complaints within a short time. The location and remedy of insufficient supply due to mains is described on page 351, and we are now concerned only with the piping between the main and the burner. Before giving the methods of locating the trouble, it will be well to describe the two classes of obstructions and their characteristic phenomena. The first class is condensation, liquid or solid, and the second class is foreign matter, usually rust or jointing material and, more rarely, other substances left in the piping during installation.

A liquid stoppage, unless complete, will be evidenced by regular pulsations of flow as shown on a flame or pressure gauge. As a rule, the pulsations are rapid enough to create a jumping flame, and almost invariably the stoppage can be looked for on the street side of the jump. If the stoppage is complete, it may be distinguished from a solid stoppage only when the location admits the use of an investigating wire. However, as condensa-

tion is caused by a chilling of the gas, it always should be looked for in any visible trap in the piping—as the meter—and in any other locations, such as services, that may be exposed to low temperatures and in which unsuspected traps may exist.

Solid condensation generally exists in the shape of frost, and is the form assumed by oil or water vapors condensing out of the gas at temperatures below freezing. With normal service and meter installations these frost troubles will not be experienced seriously except during a cold spell of several days in which the temperature approaches zero. The frost is deposited in layers extending from the pipe walls, and a frost stoppage, unlike a liquid one, is not restricted to a trap. Indeed, a frequent place is in vertical piping located on an exposed wall, and for that reason such a position is prohibited by modern housepiping specifications. The larger sizes now specified also tend to make piping more immune to complete frost stoppage, because the severe weather is often at an end and the frost melts before the formation has become so thick as to cause insufficient supply. (See description of anti-freezer, page 399). A frost stoppage is at once complained of by the consumer, and, under good management, is promptly remedied by the company. This remedy should involve, especially for recurrent complaints, any change in company structures necessary to end the trouble, and in the case of exposed housepiping, it often may be cheaper to alter its location than to answer repeated complaints.

Ice is another form of solid condensation which occurs more rarely than frost, because it is due to the freezing of a liquid stoppage, and usually this liquid stoppage, forming in mild or not very cold temperatures, would be complained of and removed before the advent of weather cold enough to make ice.

Foreign matter, in its usual role of causing a partial stoppage, is more to be dreaded than condensation as a foe to good service. This is especially true in the older cities and where housepiping supervision has been lacking. In the shape of rust, it slowly accumulates at the bottom of the house riser, and in far too many cases, not only the consumer, but also the company's workmen fail to suspect this condition, and insufficient supply exists until, for some reason or other, — often a total closing off of the riser,—a proper investigation is made. The buildings in the past most apt to be affected this way were those houses of the wealthy built forty years ago, piped perhaps somewhat inadequately and exposed since to the imperfectly purified gas of the

olden days. Every workman having occasion to investigate the gas supply of such houses, should keep in mind the great probability of these rust stoppages.

Another favorite location for rust is at the junction of a small service with the main. Often no fitting was used here, the pipe being bent to a right angle and somewhat flattened in the process. This bend, or the alternative elbow, seems to collect all the rust there is. It is deposited in a more or less spongey form, so while the supply is obstructed, enough gas gets through to satisfy the consumer, probably because the deprivation has been very gradual. Some early winter day, however, enough frost is formed in among the rust to stop flow completely, or so nearly that a complaint is made, and an epidemic of such complaints is rather usual with large companies in the first cold snap.

Rust is found not infrequently in the service ell screwed into the tee on the head of the service, and its effect is shown in a manner and at times similar to those just mentioned for rust stoppages at the junction of the main and service.

Jointing material gives trouble only when applied on the female threads, especially in the small sizes. It is seldom the cause of a general insufficient.

From these general remarks on the obstructions themselves, we pass to the steps taken to locate an obstruction. When the order locates the trouble at some particular burner or fixture, there is usually a proper supply elsewhere, but it is good practice to test before leaving, the flow at some burner near the meter. When the failure of supply is more or less general, the first step should be to light the burner nearest to the meter. This will show whether the stoppage is on the street side or not. If it is, the next step would be to disconnect the inlet connection and open the meter cock momentarily. This will generally indicate whether the trouble is in the service or in the meter. Also, if there is liquid in the service, a gurgling noise, produced by the passage of the gas over the liquid, may be sometimes heard.

In the foregoing, it has been assumed that the stoppage was great enough to be traced by the comparative size of a flame or by the feel of a gas stream as it issued from a cock. There are, however, a number of instances where the amount of gas passing by the obstruction is sufficient to supply adequately one or a few burners in any part of the building. In that case, in order to determine the location of the trouble, it may be necessary to take simultaneous pressure readings at different points between the

head of the service and the farthest burner, while all or most of the burners and appliances are in use. Such observations are especially necessary when there is more than one obstruction, or when there is none and the lack of supply is due to the demand for gas being greater than the unobstructed pipe can supply. Should there be much variation in main pressure at this location during the 24 hours, the above pressure readings should be taken at a time when the main pressures are lowest.

Remedy at Specific Locations

Service

We will now assume that the stoppage has been located in the service. The removal usually involves opening the service at the wall, though in those situations where there is no curb cock and a service cleaning device (Figure 69, page 202) is not used, it often may be advisable to attach the force pump (A, Figure 70, page 203) to the house side of the meter cock. Thus, there is always a cock available to stop the gas flow. However, the effectiveness of the compressed air is much decreased by the fittings and piping of the meter connection. If there is no curb cock to stop the flow, two men always should be on hand before the service is opened and also while the removal of the stoppage is progressing with the curb cock open, unless a device like that in Figure 69 is used. The above requirements are amply justified by the accidents that have happened under other conditions during service clearing.

The following description refers to one workman only. The curb cock is shut. Then a wire might be inserted to explore as far as the cock for the approximate location of the stoppage, in case the latter should begin on the house side of the curb. Next the service cleaning device should be screwed on, with both of its cocks shut. Then, opening the curb cock and the flat head cock, the wire can be inserted through the $\frac{3}{16}$-inch hole in the $\frac{3}{4}$-inch plug with little escape of gas and absolute safety to the workman. The wire being withdrawn, the plug replaced, and both cocks and the meter cock shut, the force pump is connected and a charge of compressed air allowed to enter the service, by the successive openings, first, of the two cocks on the cleaning device, and then of the one on the pump. The removal of the $\frac{3}{4}$-inch plug affords a convenient means of finding out what effect any charge may have had.

A liquid stoppage of ordinary extent in a service of usual size is readily removed by a force pump. If the trap is of great

extent, it is usually impossible, even though the service may be of normal diameter, to do more than give temporary relief by scattering the liquid for the time being, and it will once more collect and give trouble. When the service is a large one, no relief is possible, and in both cases, the proper remedy is to take out the trap, the location of which may be told by progressive insertions and corresponding withdrawals of the exploring wire until its end shows wet.

If it is cold weather, the stoppage may be frost, or frost and rust, or, more rarely, ice. To remove any solid stoppage not due to frost, the service cleaning device should be attached and a considerable quantity of liquid (alcohol or water) poured into the service. This has the effect of softening the stoppage, which consists usually of rust, and preparing it for proper response to the wire and the charge of air, which should follow. When frost is a contributing cause, alcohol should be poured in through the cleaning device and, after two or three minutes, the pump used to clean the loosened frost. This routine should be repeated until complete clearance is effected. No standard quantity of alcohol can be mentioned as sufficient to remedy any stoppage, and sometimes as much as a gallon is necessary. If the stoppage is ice, as distinguished from frost, hot brine or water is more effective than alcohol.

If two men are present, the service cleaning device is not so necessary from the standpoint of safety, and the liquid may be poured directly through a service ell screwed into the plug opening at the head of the service, and left pointing upward. After the liquid has entered, this service ell can be removed and the wiring and pumping done through this same hole, more effectively than when the cleaning device is used.

A workman unprovided with cleaning device, wire, or pump, may sometimes, if the frozen stoppage is not too solid, remove it by pouring the thawing liquid into the upturned meter inlet swivel, the meter cock being closed, and then placing his thumb over the end of the swivel and, opening the meter cock, allowing the liquid to run into the service pipe. Then the meter cock should be closed and the operation repeated until the desired result has been obtained. This same procedure will soften or perhaps entirely remove a very hard stoppage by the time another man has arrived with a pump.

A frozen stoppage which is due to the freezing of liquid in a trap, will, when thawed out, still present the problem of liquid stoppage.

Another method often used successfully for solid stoppages employs the drip pump (G, Figure 44, page 166) and water—salty for a frozen stoppage. The service is filled with liquid, the pump screwed on and primed, and the suction accomplishes what pressure may have failed to.

The advantage of suction as used above is that the full force of the vacuum thrown by the pump is available in the service. When using a force pump in the ordinary way, the expansion of its contained air as it enters the service very materially weakens the force exerted against the obstruction, especially if the service is a large one and the trouble some distance from the house end.* To overcome this handicap, pressure may be pumped up in the service and the pump simultaneously, by closing the curb cock and opening the various cocks between the pump and the service. (If, by chance, the stoppage should be complete and on the house side of the curb cock, the latter would be left open.) Then when the curb cock is opened, a very strong force is exerted against the obstruction, solid or liquid. This method, however, results in throwing upon the service a pressure much heavier than that to which it is normally accustomed. It should not be used if there is any evidence that the service is appreciably corroded. It always should be followed by a 6-inch pressure test against the curb cock to make certain that no leak has been started, and by smelling at the stop box. In using this method, the relation of the volume of air compressed in the service to the capacity of the main into which it will escape, should be considered, and where it is thought there may be danger of neighboring consumers being affected, proper precautions should be taken, such as lighting burners in adjacent buildings and watching them until there are no more signs of an air mixture. Under these conditions, much of the mixture may be disposed of through a hose attached to the service and extended through a cellar window.

The solid stoppages due to rust being usually found at the main, are at a great distance from the house end of the service

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* The initial pressure in the pump itself varies from 10 to 40 pounds, the average being perhaps 20. The volume of air discharged at this pressure is, however, very small. It is probably true that the momentary pressure in the pipe being cleared out, does not rise above 5 pounds. The obstruction usually is removed so quickly that this momentary pressure is dissipated before any damage is done. In hundreds of cases, a careful gas test, applied after pumping out a system of piping, shows that not even the fixture key grease has been disturbed.

and for that reason are hard to reach. Also, especially in the small services, the rust is generally more or less packed in the bend of the service and often impossible of removal. Either the suction or the service reservoir method offer the best mode of attack, but often because of the age of the service, may not be used. There is always a danger, with any pressure method, of packing the stoppage more compactly and converting a partial into a total stoppage.

The precaution of having two men on hand when doing certain work without the cleaning device, has been mentioned. Another very important point is to be sure that neither suction nor undue pressure be thrown on the meter. Therefore, unless the inlet connection is broken, the meter cock should be kept closed when working on the service. Again, when any service that appears or is known to be old, has been wired or pumped, a 6-inch pressure test and an examination of the stop box should follow. Neglect of this precaution is bound to result in some service leaks, discovered after the workman has left, any one of which might have serious results.

There may be no stoppage in the service and yet it may be the cause of the insufficient supply. In some cases, this can be known at once by comparing the consumption of the building with the capacity of the service pipe as given by a computer. Often, however, the taking of pressures is the only satisfactory way to prove the inadequacy of the existing pipe. For instance, if the pressure in the main as known, or taken at the time, is 2.5 inches, and the pressure at the house end of the service during the maximum consumption is 2.2 inches, practically 0.3 inch may be gained by enlarging the pipe, for in a service of normal length the drop is usually less than 0.1 inch. Whether, in the particular example cited, an enlargement would be advisable or necessary, would depend upon the use to which the gas was put. For lighting with inverted mantles, with a requisite burner minimum of 2 inches, more than 2.2 inches is required at the service outlet, because the meter generally absorbs 0.3 inch and the housepiping often as much more. However, the ordinary case of insufficient service size will disclose a greater pressure difference than that quoted, and if there is an instantaneous water heater in use, the first place to look for trouble is in the service or in the meter.

Where there is a curb cock in use, a careless turn-on man, by leaving the cock only partly open, may cause insufficient supply, and, therefore, on all such complaints the curb cock should be examined.

Meter

Most of the cases of insufficient supply caused by the meter betray their origin by peculiar symptoms recognizable by a trained workman. Two causes, the effects of which are somewhat similar, but which are rather difficult of distinction, are a demand beyond the normal capacity of the meter (see table on page 456) known usually as an "overload," and a sticking or binding of the mechanism at some particular point in its revolution, known as a "works catch" (see page 556). The effect of each usually is a certain though variable amount of fluctuation, and always a reduced pressure. However, an "overloaded" meter ordinarily, although not by any means invariably, maintains the reduced pressure with little, if any, noticeable fluctuation, while a "works catch" always produces a distinct and generally a regular slow fall and quick rise in pressure. The "overload" conditions can be verified by noting the rate of consumption shown by the meter test hand, or in aggravated cases, simply by a glance at the number or kind of appliances supplied. A workman investigating a complaint of insufficient supply at a time when some or all of the appliances are out of use, should be especially careful to consider the possibility of a meter overload. The "works catch" condition usually may be recognized by eliminating the possibilities of overload and of water in service, meter, and piping, and then by lighting one or more burners, preferably of the open-flame type, and watching the flame for a regularly timed slow fall and quick recovery. An aggravated "works catch" frequently becomes a "won't pass gas" (see page 543), which implies a total stoppage, and which, in mild weather, is the most probable cause of such a complaint. This cause may be analyzed as a "won't pass gas" if, under such conditions, there is sufficient supply at the meter inlet connection and none at the outlet column, while there is no water in the meter or its columns. To remedy any of these three conditions,—"overload," "works catch," and "won't pass gas,"—a new meter should be set.

Condensation in the channels (Figure 121, page 440), or in the body of the meter, may be the cause of an insufficient supply. It can be present in a channel only after the lower part of the corresponding column has filled up, but after that point has been reached, a very slight additional quantity entering the channel is sufficient to cause a complaint. For this reason, it is seldom that a "won't pass gas" condition is reached. Condensation is found more often in the outlet column and channel than in the

inlet, because the length of piping which may drain toward the meter is so much greater than that on the inlet side. Condensation in the channels may be recognized by the "rushing" sound that is noticeable within the meter while gas is passing through. Its effect is to restrict the flow and to cause that rapid jump of the flame that usually is characteristic of all water stoppages, and which is easily distinguishable from the fall and rise produced by a "works catch," or sometimes by an overload. The remedy is first to pump the columns dry, using the meter column pump (B, Figure 70, page 203); then to tilt the meter so that the condensation in the channels will run into the columns, and then to use the pump again. The long channel of the prepayment meter is trapped by its construction, and cannot be thus cleared, but experience shows, however, that condensation does not accumulate in this long channel. Liquid is very rarely found in the body of a meter in such quantities as to seriously affect the action. Although it is physically possible to remove condensation both from the columns and channels, or from the body of the meter, by turning it over, it is not advisable to do so, because in this way liquid and solid particles from the measuring compartments get between the valve seats and faces and interfere with the meter action. If it becomes necessary in an emergency to use this method of removing condensation, the meter should be replaced within a short time. When water is present in a meter exposed to very low temperatures, it may be frozen stiff, and so stop the meter. The remedy is to apply hot water or hot cloths to effect a thaw.

Prepayment mechanisms get out of order in such a way that no more gas may be bought, and these troubles, therefore, come under the head of insufficient supply. The instructions that follow apply to repairs advisable without meter removal, to the mechanisms illustrated in Figures 127 (page 448), 128 (page 450) and 129 (page 452).

Any of the parts numbered in Figures 127 and 128 should be replaced if defective. If coin cannot be inserted, this may be because the handle has not been turned far enough toward the back of the meter to allow last coin inserted to drop into the cash box. First turn the handle all the way back and shake it gently, listening for a dropping coin. If the coin is heard to drop, it is probable that no mechanical trouble exists, but, if desirable, this can be verified by obtaining another coin from the consumer, inserting it in the meter, repeating the operation of

prepaying for gas and making sure that the credit hand has moved properly, and that the prepayment valve has been opened. If there is reason to suspect that the article that was preventing the insertion is not a perfect quarter, or if the valve is not opened by the insertion of a coin, the cash box and the slot part (2, Figure 127) should be removed, so that the contents of the box can be seen and the prepayment mechanism examined, as explained later on. If no sound of the dropping is heard after turning the handle all the way back, or if no additional coin can be inserted, or if the handle cannot be turned at all, the trouble may be due to a tin tag or imperfect coin being stuck. In such cases, remove the slot part, take off the buffer plate (4, Figure 127) and remove the article, if this can be done without injuring the mechanism. When it is not possible to remedy the trouble permanently, if the consumer needs gas, and if the prepayment valve can be opened by turning the gearing by hand, this should be done, the requisite movement of the credit hand, to insure the proper amount of credit for the money obtained from the consumer, being determined by a gauge provided for the purpose and held against the credit dial glass. If the valve cannot be opened by hand, service cannot be restored until a new meter has been set.

If the trouble is due to a defect in the prepayment mechanism, the slot part should be removed and the mechanism examined and repaired in accordance with the following rules: Test adjustment of coin carrier by dropping the coin in the slot as far as it will go and, if necessary, turning the 50-tooth wheel (3, Figure 127,) until the coin drops all the way in. Then turn the handle to let the coin drop through. This buying operation should be performed three times in succession. Examine 50-tooth wheel to see that teeth are perfect; if not, put on a new wheel, hub side first. If the 50-tooth wheel is loose on shaft, tighten the set screw, exercising care to see that it engages the flat of the shaft. Examine the intermediary wheel (4, Figure 128), and if teeth are not perfect, put on a new one. Examine the price wheel (2, Figure 128), and if it is not perfect, put on a new one. Any operation that might inadvertently shift the position of the price wheel should be very carefully done, to avoid such shift. As a precaution, before doing any adjusting, a mark should be made on one of the teeth of the price wheel, and a similar mark, just under it, on the gear box. These two marks should register after all the adjust-

ing has been completed. As an additional safeguard, the original position of the credit pointer should be marked on credit dial box. Now see that the click (3, Figure 128) engages properly with the teeth of the intermediary wheel. Then replace the slot part and coin box, obtain a coin from the consumer, and test the correctness of the adjustment work by buying gas. It is important to avoid turning any gear wheel by hand while the slot part is on the meter.

When it is necessary to renew a complete slot part, a certain amount of fitting is required in many cases, before the slot part will fit accurately to the gear box. Both screws always should be used in fastening these two parts together, a little oil or grease applied to the threads before inserting the screws being valuable in preventing rusting in.

When removing or replacing the coin box, do not jar or jerk meter. If it is hard to remove, tap bottom lightly, and then pry it off by gently inserting a tool, such as a small curved jimmy or a screw driver, between the back of the box and the meter. The pressure should be applied as near the bottom of the box as possible, the front corner of the meter serving as a fulcrum.

If it becomes necessary quickly to close the prepayment valve, this may be done by removing the slot part, lifting the click, and slowly turning the price wheel with the fingers, until its seating is felt. To relieve any undue strain, the wheel should then be turned two teeth in the reverse direction.

Governor

If the supply is controlled by a governor, and there is a general insufficient, a pressure reading should be taken near the governor outlet to determine whether the latter is set at a pressure adequate for good service. This often is not the case where gas consumers are persuaded to rent governors from a private company by the statement that a great reduction in bill will follow. To effect such reduction, the governor will be set to give a pressure often as low as 1.6 inches. In such cases, there should be no hesitation in raising the pressure to 2.5 inches, and notifying the governor company to cease such improper regulation.

There are also devices known as gas checks, which, from time to time, are sold by unprincipled persons with an extravagant guarantee of gas saving. Such a check is placed in a meter outlet column or connection, or in the adjacent piping, and, acting simply to retard gas flow, generally results in a poor

supply, which sooner or later brings a complaint. Therefore, the workman should be on the lookout for such a device when the trouble seems to be in or near the meter and no other cause is apparent.

Piping

If there is a general insufficient, and the supply has been found adequate beyond the meter or any governor outlet, the trouble should be looked for in the piping between that point and the first branch line. The likelihood of rust at the riser bottom has been already mentioned, but if none is found, and the rest of the section shows clear, the size should be checked against the gas demand. If this does not clearly show the reason for lack of supply, pressures should be taken as previously mentioned. Such pressure observations are especially necessary when there is a local insufficient, and the controlling piping being concealed, its size may not be seen. Under some conditions, it may be difficult to be absolutely certain whether a stoppage or too small size is the cause. However, if a force pump gives no relief, the only indicated cure, viz., obtaining access to the pipe, is equally efficacious for either trouble.

In using a force pump, it should be applied to an outlet on the burner side of, and as near to, the probable stoppage as may be, and the end of the riser left open. The meter outlet should be disconnected so that no back pressure will be exerted on the meter.

In the above, the stoppage, if any, has been assumed to be due to rust or other foreign material. A liquid stoppage would be detected by its peculiar symptoms, and would be blown out by a force pump, attached as already described. Also, a frozen stoppage would be looked for in cold weather in piping near meter or walls. It often will be difficult to reach such piping either from within or without. The objection to introducing any liquid thawing agent is that there may be slight traps in the piping, requiring the subsequent use of a force pump to clear. Where the piping is accessible, a steam jet may be used.

The larger the building, the greater the care needed in investigating piping stoppages, to insure that the trouble has been properly diagnosed and located, and only the best complaint man should be assigned a job of this nature, and he should be instructed to report for especial attention every case about which he has the slightest doubt.

Fixture

A stoppage in a fixture usually is very easily located and remedied. Many fixture stoppages are due to jointing material or key grease, and the first places to examine are the keys.

Policy Controlling Work

If there is adequate control over the installation of new piping, a fairly liberal policy of free work in remedying insufficient complaints, will not involve a large expense and will produce a good feeling on the part of the consumer. In any case, the company should be willing and prompt to trace the trouble to its cause, and remove the latter, unless this involves access to concealed piping with attendant removal of floors and plaster, and then some limit of labor and material is needed. This might properly be the same as that applying to leak work, or even more liberal, as consumers are more apt to spend money for the repair of a leak than to remedy cases of insufficient supply, and the cure of the latter tends to increase consumption.

Air in Piping

Trouble that affects the consumer in about the same way as does insufficient supply, sometimes is caused by air, used in gas blast appliances, entering the gas pipe, travelling back through the meter, and being carried into the systems of other consumers, either in the same building or sometimes at locations far removed from the trouble source. Sometimes this is due to the carelessness of the appliance operator, when he fails properly to close the cocks or valves on the air line and the gas line; sometimes to an improper placing of these valves in relation one to the other, or to the existence of a cock which will shut off both air and gas; and sometimes to a stoppage in the burner beyond the point of mixture. The trouble can be recognized by a normally yellow flame burning blue, by the flashing back of properly adjusted burners, and by the failure to burn of the mixture issuing from the gas pipe at good pressure. After locating the point at which the air is entering the gas piping, the remedy usually consists in closing the valves that have been carelessly left open, or in removing the stoppage that has been the cause, and then "gassing out" the systems that have been affected. The meter, back through which the air has travelled, should be changed as it is probable it has suffered internal damage.

All trouble from this cause may be confined to the system of the consumer owning the air blast appliance by a requirement

that at the outlet of each meter supplying such an appliance there be installed a valve designed to close promptly under back pressure.

PART IX

APPLIANCE WORK

Under this heading will be described the organization suitable for appliance work; the orders and records used; the influences affecting appliance design, and the details of delivery, connection and maintenance. Where routine given for cooking appliances also applies to other types of appliances, it will not be repeated in treating of these types.

SECTION I

ORGANIZATION

CHAPTER LVIII

ORGANIZATION OF FORCE

Small Towns

In small situations the organization of the force for appliance work must be of an extremely flexible nature, because the total number of employees is small, and they are required to perform street jobs and office work in addition to appliance installations.

Usually when a man is working in this way, he obtains and, if he is of the right type, takes advantage of such a good opportunity to observe the rules and policies of the company, that in addition to performing the actual physical work, he is enabled to act as his own foreman and his own inspector. He would report directly to the general foreman or to the superintendent.

As the size of the force increases, it is usual to give each man a course of training, and then, if the volume of work and the character of the territory covered permits, to confine his work to certain more or less well defined duties at which he becomes expert. With an enlarged number of workmen comes the necessity for foremen and assistants or inspectors, to relieve the general foreman or the superintendent, or both, from too much attention to details. In general, to properly oversee thirty workmen engaged in appliance work, one general foreman and four assistants or inspectors are advisable. However, as previously intimated, with a smaller force, the ratio of assistants to workmen would decrease, because each workman of the smaller force must necessarily engage in more general work and come into closer and more frequent contact with foreman or superintendent, thus making possible the quicker development of a reliable and efficient employee.

Large City

Foreman

The organization in a large city is not necessarily as flexible as that in a small town, but should be sufficiently so to insure proper service to consumers, in spite of variation of the quantity and character of the work. The appliance work would be placed under the general foreman of fitting work, as described in Chapter II. He should be a man who has risen from the ranks, and who can combine proper knowledge of practical work and ability to teach efficiency to his subordinates, with reliability, good judgment and enough education to do the clerical work that will fall to his lot. This foreman should have at least one assistant, who has obtained his knowledge of the work in the same manner as has the foreman, or who is a younger man with a technical education and who is undergoing a course of practical training for qualification as superintendent or manager.

Inspectors

The next men in line are the inspectors, who are classed as follows:

1. Preinspectors, who make the first visit or preinspection, as explained further on. These men may or may not have authority to direct the workmen who specialize on the various kinds of work.
2. Inspectors, sometimes known as subforemen, who have direct supervision of the fitters' work, and who are the connecting link between the fitter and the office.
3. Subinspectors, who make an inspection of the work a day or so after completion.

The duties of one or more of the above may be combined as working conditions permit. The number of these men necessary in any situation cannot be accurately stated, as it will vary widely with the kind of work and the extent of the inspection desired. Of the three classes of men making the various inspections, the second should be the most experienced and capable.

Workmen

Appliance connections are made by men known as fitters and helpers. The question as to the use of a one-man "gang," meaning a fitter only, or that of both a fitter and a helper, is regulated by the weight of the appliance to be handled, the size of the pipe to be fitted, and the length of time that the job will

occupy. In other words, there should be that combination of man power and economy which is most desirable. It often is found necessary to give a few fitters special training on certain classes of work which require more detailed knowledge than do ordinary installations. Work requiring this specialized knowledge is the installation of special factory appliances and of gas engines, particularly where this latter work includes the erection of a base, and of complicated water or exhaust connections.

The fitters should possess good mechanical ability, combined with steadiness and politeness, and, if possible, should be able to write legibly. As from their ranks should come the promotions to the various inspection positions, and they in turn are recruited from the helpers, in hiring the latter, particular attention should be paid to the calibre and qualifications of each man; he should be carefully observed by those directly over him, and if he proves undesirable, should be dropped at the first opportunity.

There should be some definite method of systematic instruction for all employees. This might take the form of periodic meetings, when the employees—as a class or individually—would receive instruction in all subjects of mutual interest to themselves and to the company.

CHAPTER LIX

ORDER AND RECORD ROUTINE

WORK COMPLETION SCHEDULE

REASON FOR SCHEDULE

A schedule, showing the maximum time allowed, in full days, for the completion of an order after its receipt by the shop, should be arranged and strictly followed, so that in addition to insuring impartial treatment of consumers, the salesmen and clerks will be enabled to furnish prospective purchasers and other consumers desiring attention, with the probable date of completion of installations and miscellaneous work.

CONSIDERATION IN MAKING SCHEDULE

Considerations influencing a work completion schedule are:

1. The value to the consumer and to the company alike of prompt attention to all work as ordered.
2. Economy in performance as affected by speed of completion.
3. Geographical distribution of the work.

SAMPLE OF SCHEDULE

The following is a sample of an appliance work completion schedule. The term "Line in" indicates that the appliance line is already installed and, therefore, the physical work of connection is comparatively simple.

Appliance	Conditions	Time to Complete (In days)
Range	No line in	4
"	Line in; range to be delivered	3
"	" " " on premises	2
Circulating water heater	—	4
Automatic instantaneous water heater	—	6
Small miscellaneous appliances	—	2
All other fuel appliances	—	4
Lamps or burners	On existing outlet or fixture	2
" " "	Piping required	3
Complaints	Urgent	0*
"	Not urgent	1

* Zero means completion of order on day of receipt.

Order Cards

How Originated

An order card may be originated as the result of a verbal, mailed or telephoned communication. Orders thus originated are known as "Complaint Orders," or simply "Orders," Figure 189. They usually call for work of a comparatively simple nature, and do not require ledger or book entries on their completion. A convenient size for all order cards is 3 by 5 inches, or multiples of that size.

REC'D BY REC'D FROM PHONE NO.	VERBAL - MAIL - PHONE ORDER NO.	**ORDER** TIME DATE
LOCATION		
NAME		
NATURE OF ORDER		
FINAL REPORT		
FINISHED BY		DATE

Figure 189.—Complaint Order, page 663.

Orders of more importance, especially those requiring material or appliances to be furnished and installed, are usually originated by a salesman. The order as written by the salesman on the sales form may, with profit, be typewritten on a standard charge order, as the form best suited for sales purposes is not well adapted for subsequent handling by the distribution force. (See Figure 190).

Use of Order Cards

The use of an order card is, first, to serve as a notice that attention to certain matters is necessary; second, to afford a current record of the work done and the result obtained; third, to notify the office of work completion or additional requirements, including any auditing or recording affected by this work; and

ORIGINAL—COMBINATION SUNDRY ORDER

SYMBOLS √-YES. O-NO.

Rec'd at.................Date.................191...... Time........A. M. P. M.

DISTRICT

Terms ....

.................(Charge) (Paid) ....

Ordered by ....

Per..... ....Relation ....

Gas in Name of.................

....

Clerk................. IF A G. S. DOES IT MAKE NEW GAS KITCHEN? ....

DISPLACE-MENT? ....

MAIN IN?	SERVICE IN?	USING GAS?	REG. OR PPD. APP.?	HOUSE PIPED?	FLOOR?	IS A FORM 677 ATTACHED?	
				FOLD			

Address.................

Name ....

DO WORK

BILL No.	4658	CHARGE ORDER No. AND DATE

FINISHED BY	DATE	LINE IN ?	
INSPECTED BY	DATE	ACC'T	AM'T PAID

1	17
2	18
3	19
4	20
5	21
6	22
7	23
8	24
9	25
10	26
11	27
12	28
13	29
14	30
15	31
16	

Figure 190.—Sales Order, page 663.

fourth, to constitute a permanent history of date and details of work and of names of employees who have visited consumer's premises.

INFORMATION NEEDED

When originating an order card, the nature of the work desired should be clearly and explicitly stated, in as few words as possible. On complaint orders, sufficient information should be given to make unnecessary the consumer's repeating to the workman the important facts already related at the time the order was originated. On orders for charge work, the important

features are a standard form of arrangement and expression and a brief statement of any peculiar instructions that should be known in order intelligently to complete the work.

The workman should use care when writing his report, to make it complete, exact and brief, placing the data necessary at the precise place designated on the card and noting especially any work done which is not indicated in the "Nature of Order" as originally written, or any work indicated originally which was not done, the reasons for every variation being carefully explained.

Course Through Shop

The course through the shop varies to some extent with the nature of the order. Broadly speaking, all orders are treated alike, except charge orders, which require a slightly different treatment.

Noncharge Orders

These orders reach the shop in duplicate. From the nature of the order, and as indicated by the work completion schedule, the date of completion is determined. The duplicate is filed geographically in the space alloted to all other orders due on the same date, and remains in file for purposes of record only, while the original is uncompleted. The original card is placed with others due on the same day, and is then forwarded to the workman via the dispatching clerk. If completed on the first visit, it is compared with the filed duplicate, which is then destroyed. The original is audited for correctness, and is permanently filed as history. If the order is not completed on the first visit by the workman, but it is found that repair parts for the appliance are needed, or some other delay is necessary, this information is posted on the duplicate, which continues to serve as a record of uncompleted work, while the original acts as a memorandum in ordering the repair parts. When the proper time arrives, the original is again assigned to the workman for completion.

Charge Orders

Charge orders also, whether in the form of sales slips or typewritten cards, arrive at the shop in duplicate. The date on which the order is to be completed is determined, and this date is indicated by checking the proper numeral printed along the right-hand edge of the order card (see Figure 190). A stamp is then placed on the card indicating the account to which the time of the workman is to be charged and giving the class of appliance, the latter information being used in the audit. The original

and duplicate are filed and treated in a manner differing only in minor details from the system already described, until the work is completed. At this time the duplicate is removed from file and accompanies the original to the storekeeper. Charge cards are very carefully audited to make sure that there is no discrepancy between the work ordered and that actually done. This is of particular importance, as any mistake would effect the accuracy of the bill rendered. In case the order has involved the issuance of appliances or certain kinds of material (see Chapter LXXXIII) the appliance and material shown (as chargeable) on the original card are indicated in a similar manner on the duplicate, and the latter is forwarded to the store room, there serving as a record of the issues from stock. The duplicates of charge orders not demanding material or appliances may be destroyed on completion. The original order is sent to the commercial department for billing, after which it is filed as a historical record.

Work Records

When the issuing, auditing and filing of orders is properly done, the order card itself is usually sufficient to serve all purposes of record. There may be records of various kinds found necessary under certain newly inaugurated practices which require the keeping of certain data on special forms. Such records are usually made at the time of audit. Into this class of record would fall those of hotel cooking appliances which are under maintenance, of automatic instantaneous water heaters which are inspected periodically, and of any appliance newly placed on sale, of whose performance a record, under various conditions, is desired. In addition to such records, a careful daily account is kept of the number of appliances of each class installed and of the other classes of work completed. In this way are obtained divisors for the cost reports, as explained in Chapter IX.

The filed order cards, forming a history of all physical work done by the company's workmen, are used to furnish any details made necessary by request of consumers, often some time after the work has been completed.

CHAPTER LX

INSTALLATION ROUTINE

Preinspection System

Definition

In the preinspection system of installation, the first step taken by the distribution department, after the receipt of the order, is a visit of the preinspector, as before defined, to the premises. He discusses the installation with the consumer, makes a list of material necessary, and, by virtue of the knowledge thus obtained, is able to note any special instructions which will be needed by the workman at the time of connection. This system is thus distinguished from any other by which a standard amount of material is delivered immediately after receipt of the order, the workman arriving before an inspector, and the collection of the unused material being necessary on the completion of the work.

Value

The value of this system lies mainly in the advantage gained, both by the consumer and the company, by reason of having a high grade man make the first visit, thus assuring a mutual understanding on all questions in doubt, such as the location of the appliance and its connections, and the date when the work can be started. Another advantage is the saving made where the preinspector finds that the order has been cancelled by the consumer, for then the trip of the preinspector is the sole loss, as compared with the trip of a delivery wagon entailed by any other system. There is also a considerable saving in transportation through not having to carry out and in unused material, the amount delivered under this system being as nearly exact as possible.

The preinspection system becomes less necessary, and even inadvisable, when the work to be done is of comparatively small extent, or when its completion is called for on a one-day schedule. This condition exists principally in the installation of small

appliances when connection work is simple, and of any appliance when the material required to connect is definitely known and there is no likelihood of any special points about the work being necessary of settlement beforehand.

Calibre of Preinspector

The preinspector should be experienced in all branches of fitting work, familiar with the rules and policies of the company, the operation and application of all appliances, and should be on the alert to discover and to correct any false impressions in the mind of the consumer.

Delivery

Appliances

When conditions are such that the company has on sale appliances which are manufactured or handled by a local manufacturer or dealer, it may be advantageous to both company and dealer to arrange for the appliance to be delivered from the latter's stock direct to the consumer's premises. The advantages to the company, not considering any difference in the cost of the appliance under another method of delivery, are the saving of hauling between shop and consumer, and the practical elimination of appliance stock with the entailed economy in storage space and invested capital. On the other hand, there is the disadvantage of the uncertainty of prompt delivery, especially in rush seasons, the fact that the visit of the dealer for delivery is, to the consumer's mind, an extra visit, and also the possibility that an appliance thus delivered has not always received in the factory the careful inspection made in the company's storeroom. This last possibility necessitates more careful inspection by the fitter and the subinspector.

In general, any appliance should be delivered in a location on the consumer's premises where it will not cause inconvenience or be liable to damage from any cause. Some types of appliances may need crating before delivery, and others may require delivery in a partly unassembled condition.

Material

When possible, delivery of material and of appliance should be made at the same time. Material should be delivered in properly protected bundles, either strung or in containers, and should be stored by the delivery man in a suitable place and where it will not be a hazard to the public. As a partial pre-

ventative against loss by theft, a notice might be printed on the delivery tag stating clearly that all of this material is necessary to properly perform the work, and that its theft will cause delay and inconvenience.

Supervision and Final Inspection

Necessity for

The necessity for supervision of appliance work varies with the class of work and the calibre of the workman. Supervision of ordinary type installations is necessary only to insure sufficient work output. Where there are special cases continually occurring, each calling for a decision which the workman is not capable of making, at least one visit of the inspector to the premises during the progress of the work is good practice. On installations of special appliances, and of any large appliance of a make with which the workman is unfamiliar, the supervision should be close, requiring sometimes the continued presence of the inspector to prevent mistakes. These cases benefit the inspector as well as the workman.

Final inspection, meaning a visit of a subinspector within a day or two after the appliance has been placed in operation, is necessary on all installations of ordinary appliances where the workman is considered unable, or, for reasons of speed, has been instructed not to make the adjustment; in all cases where it has been found that a certain type of appliance develops objectionable features after a short time in use; and on all installations of special appliances, such as factory blast appliances or gas engines, where the method of operation by the consumer affects, to a large degree, the results obtained.

Extent of

As partly explained in the preceding paragraph, supervision should extend systematically to every kind of work, the percentage of the total installations which are supervised being a matter to be decided in each particular situation. Final inspection, whether or not this work is delegated to the workman who makes the installation, and is made immediately after its completion, should be made of every appliance installation. The details of what this inspection is intended to cover is explained hereafter under each class of appliance.

Who Best Fitted to Make

The qualities desirable in a man used in supervision are ability to obtain the best results from the workman, and a

thorough knowledge of the company's rules and policies. The final inspection, if it be merely one of ordinary installations and one made mainly to be assured of proper adjustment, does not need a man of particularly wide experience, as this work will be practically of uniform character and may be taught to any employee in a comparatively short time.

Relation of Shopman to Salesman

What Salesman Should Know of Shop Practice

A salesman should be familiar with all the operations in the shop which are necessary to complete an order after its receipt. This knowledge should include familiarity with the multitude of reasons beyond the control of the company which sometimes tend to delay the execution of any work. He should be able, from experience and knowledge of physical conditions, to so lay out simple installations without the aid of the shopman that no subsequent change will have to be made because of the discovery of existing conditions not previously taken into account. He should be familiar with the standard terms and vernacular of the gas business, and should not only know the company's rules, but should appreciate that there is a reason for each one and should understand what this reason is. If feasible, the best way for a salesman to obtain this knowledge is actual physical contact with the shop work for a definite period of time.

What Shopman Should Know of Sales Practice

All workmen, to as great extent as possible, and all inspectors and foremen should be instructed in the best application of appliances to varied conditions, and especially in the case of installations of appliances with which they are unfamiliar, should be instructed to be extremely reticent in making any criticism of the salesman's plans. However, any disregard of important rules should be considered and decided by the proper authority before installation is made. The shopman should try to appreciate the difficulties under which the salesman must sometimes labor and should be able to make in a reasonable and diplomatic manner, whatever explanations to the consumer are made necessary by a change in the salesman's plans.

CHAPTER LXI

MAINTENANCE ROUTINE

Classes of Maintenance

REQUEST

The proper maintenance of an appliance is perhaps more important than its correct installation, because with proper maintenance any installation faults are bound to be corrected, but inadequate maintenance will largely defeat the aim of correct installation, viz., the combination of large consumption and a satisfied consumer. From the standpoint of both the consumer and the company, satisfactory maintenance means few visits at small cost, because many visits usually indicate unsatisfactory appliance conditions, and a high cost is detrimental, no matter how borne. In the past, the usual company policy has been to invite complaints and promptly to remedy them, doing a reasonable amount of free work and charging not more than cost for the more extensive repairs. This has involved, for prompt and efficient service, having available at all hours a trained force, and has been called "request" maintenance. It has been very much abused by certain consumers who are continually complaining for trivial reasons and trying in many ways to impose upon the company; but, on the other hand, there are many consumers who fail to take advantage of the company's advertised willingness to help, either because they are ignorant of the help available, or do not realize that there is anything to correct, or fear the cost will be too great. Often this failure to complain produces unsatisfactory and expensive appliance operation, and this, in turn, reacts unfavorably to the use of gas. To overcome this condition as far as may be, many companies have supplemented "request" with "periodic" maintenance. As the name indicates, it involves periodic visits for appliance examination and any needed repair, the frequency of visits being governed by the class of appliances and also by local conditions.

As a few instances, large installations of hotel appliances may, with advantage, be visited often, some every week; certain industrial appliances may need attention every month, and automatic instantaneous water heaters at periods varying from two to twelve months. As regards illuminating appliances, periodic maintenance is still in an experimental stage, although several situations report a successful experience extending over a number of years.

FREE

The amount of free maintenance work done by any company will be governed by its general policy and attitude toward the public, perhaps by its franchise, and also should be influenced largely by competitive fuel and light conditions. Some of this work will be on connections, appliances and accessories, whether or not installed or recommended by the company. Some rules characteristic of a liberal policy are given below. The repair of leaks and the remedy of insufficient complaints would be governed by the principles described in Chapter LVII.

> When the complaint is due to trouble within the appliance, it is remedied free, provided no parts or much other material is needed. A very large proportion of complaints of appliance operation can be remedied permanently by an adjustment of the gas mixture, or a cleaning of the burners or burner cocks, or a greasing in of leaking or stiff burner cocks.
>
> If the complaint is of missing or defective appliance parts, these are replaced free if the complaint is made within one month of installation, and if it is thought either that the fault actually lies with the company or that the work is advisable to retain the good will of, or to obtain further payments from, the consumer.
>
> When on any complaint it is thought that the company is responsible, a free repair or replacement is made, regardless of the length of time elapsed. When enameled range parts are in question, and the defect is trivial, a liberal rebate is offered, and if accepted by the consumer, is a most satisfactory settlement from the standpoint of the company, because of the difficulty of obtaining perfect enameled ware.

Even with a liberal policy of free maintenance, there remains a very large amount of work necessary to keep the appliances in proper operation, and which economic considerations pre-

vent any company doing without charge. This is composed principally of the replacement of broken or worn-out parts, and of complete overhauling of any appliance which is dirty or generally out of repair. Such work involves large tanks for completely immersing and boiling dirty appliances, keeping a large stock of repair parts, many of which may be very inactive, and maintaining shop equipment for making and repairing parts no longer obtainable from the manufacturer.

SECTION II

COOKING APPLIANCES

CHAPTER LXII

DESIGN

Introductory

There is a continual development and improvement in the design and construction of gas cooking appliances, and, therefore, it would be useless to describe in detail what might be considered now the best example of each type. The manufacture of these appliances is, and will continue to be, governed by the *Standard Gas Range Specification* of the American Gas Association, and a familiarity with this specification is essential to a thorough appliance knowledge. It is not given here as it is subject to change and is always easily obtainable in its latest form. Our text will be confined to the salient features and the reasons for certain constructions of the various parts which make up a cooking appliance, and to a few appliances used for special purposes. (Hereafter, in this chapter, "appliance" will mean a gas cooking appliance.)

Those who have been responsible for the development of the gas range (the typical appliance) have had before them constantly the fact that these appliances, in actual practice, are used by people many of whom have little or no interest in, or knowledge of, mechanical apparatus. The gas range, therefore, had to be a device simple to operate and one which would require little or no adjustment at the hands of the user or by the gas company. Sturdiness, simplicity and ease of operation, therefore, are primary requisites. Thermal efficiency,—that is, the ability to perform the greatest amount of useful work by the use of the smallest quantity of gas,—naturally was to be desired, but was

not to be arrived at by the sacrifice of the aforesaid primary requisites.

These facts are mentioned because the thermal efficiency of the gas range is low, when compared with some other heating appliances; but when we consider the matter of over-all efficiency, which includes not only thermal efficiency, but sturdiness, simplicity, ease of operation, wide scope of work, and lack of need of adjustment, then we may safely say that the gas range of today is, all things considered, as efficient as any other commercial household device now in general use.

In the operation of a gas range, there are simple methods which result in great economy in the use of gas, and there are other methods which result in waste and extravagance in such use. Cooking demonstrators, familiar with actual conditions, make the statement that in the average household, the same amount of cooking could be done in the same time by the use of one-third of the amount of gas. Top burners are lighted under articles to be cooked and are kept full on during the entire cooking period, when the proper use of the range would demand that the burners be turned on full for a minor portion of the time, and that thereafter during the major portion of the cooking operation, the burner be reduced by three-quarters, or, even better, the cooking be completed by the use of the simmering burner. Investigations have proven that fully 75 per cent of the total gas used by the range is consumed by the top burners, and it is with these burners that the greatest tendency is to be wasteful. It is logical to assume, therefore, that as great, if not greater, economy may be effected in the use of gas for cooking purposes by the education of the people in the proper use of the gas range as by any increase in the thermal efficiency of the burners.

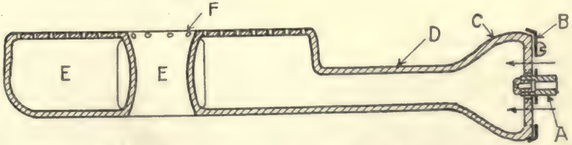


Figure 191.—Vertical Section of Typical Burner, page 676: A, Cock; B, Air Shutter; C, Mixer; D, Burner Tube; E, Burner Head; F, Ports.

Burners

General Principles

The burners of all appliances are (with the exception of a special type known as a surface combustion burner, to be described later) simply atmospheric (bunsen) burners, the primary air being drawn in by the injector effect of the moving gas. These burners are of various shapes, as called for by the conditions of their use. Before describing each form, the general principles involved and the different parts of a typical burner will be considered. Figure 191 shows diagrammatically, in vertical section, the cock A, air shutter B, mixer C, burner tube D, burner head E, and ports F. The gas stream, entering the mixer, is regulated in quantity by the size of the cock orifice, and through its high velocity exercises an injector effect drawing air into the mixer from the room, as indicated by the arrows. This quantity of air is regulated by the position of the air shutter, as later explained. The burner as a whole is a simple and compact instrument for the utilization of the heat units in the gas.

However, there are certain mishaps to be guarded against in its application not only to cooking appliances, but to many other appliances using gas as a heating agent. These will be considered at this point.

First.—The burner design must be such that a sufficient supply of secondary air reaches each port.

Second.—The combustion chamber must be of adequate dimensions to allow complete combustion. This requires that there should be no surface impingement, and, therefore, cooling of flames with consequent formation of the harmful products of incomplete combustion.

Third.—The passage from the combustion chamber to the exit of the heater must allow a free issue of the products.

Fourth.—The burner may ignite in the mixer. The result may be incomplete combustion, and its characteristic odor will be accompanied by a slight roaring noise, so that, in general, this faulty ignition will be quickly discovered and remedied.

Of the above, the second and third conditions need especial attention in water and room heaters.

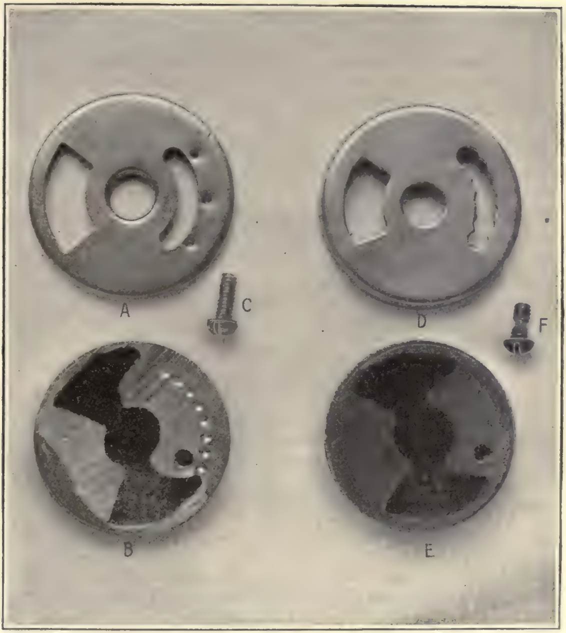


Figure 192.—Air Shutters, page 678: A, Shutter; B, Mixer Face; C, Set Screw; D, Shutter; E, Mixer Face; F, Set Screw.

Air Shutters

The air shutter is one of the important parts of a burner, because a faulty shutter results in a poor burner performance and also in increased maintenance expense. Repeated investigations have shown that a majority of complaint orders referring to cooking appliances, are caused by improper adjustment, and in most of these cases the shutters have been jarred, or accidentally moved in other ways, from their correct positions. Therefore, a satisfactory shutter is one which is easy to adjust and which,

when once set to admit the proper quantity of air, is protected against an accidental change of adjustment. The more recent designs, Figure 192, provide for locking the shutter in any one of about eight positions, and it cannot be jarred out of place with any slight loosening of the set screw. The indentations in the shutter A engage a series of indentations in the mixer face B, and the set screw C must be loosened a full turn before the two surfaces are separated sufficiently to allow any rotary movement. In D, the slot is serrated and fits the set screw F snugly, so that no change in the shutter position is possible, except when the screw has been turned to a position where the notched section is in the plane of the shutter. Either of these types should give satisfactory service; they are more convenient than an earlier form which provided fewer adjustments and where each adjustment necessitated a complete withdrawal of the set screw. They are a great advance over the still earlier designs, which were liable to shift out of position.

The shutters illustrated are of stamped sheet steel, of thickness sufficient to obtain the stiffness necessary to prevent any change in shape. Nickel-plating is added for the sake of appearance. In a few cases cast or malleable iron is used. It is clear from the illustrations how a revolution of the shutter will change the area of opening into the mixer.

Cocks

Second only to air shutters as a source of annoyance and expense have been the gas cocks, and, therefore, much thought has been devoted to the development of a design which, when properly made, would need a minimum of attention after installation. Such a design is secured in the Standard Gas Range Cock, adopted by the American Gas Institute in 1914 and described, with accompanying detailed drawings, on page 1513 of its *Proceedings* of that year. Figure 193 is a drawing of the assembled cock as provided with a flat metal handle. Its most important features are:

(1) Ample bearing surface above and below the gas way and around the plug.

(2) A spring at the plug bottom, to maintain a light constant pull on the plug, causing it to bear uniformly on the barrel and to advance as wear occurs.

(3) A sufficient gasway.

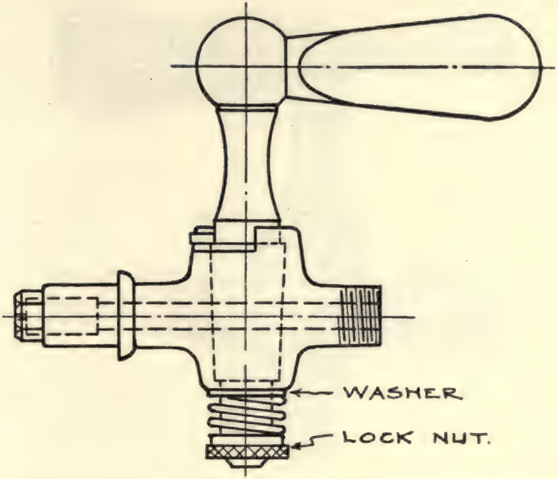


Figure 193.—Range Cock Drawing, page 678.

(4) A quarter-turn stop, allowing but one "off" and one "on" position.

(5) A metal of proper composition.

(6) Good appearance.

The lack of (1) and (2) has resulted in many annoying leaks; (3) diminishes the chance of insufficient supply; (4) represents the last work in a development that began with a wheel-handle valve, which even now has its advocates, though the weight of expert opinion is against it as having a stuffing box and other complexities of design, and failing to show at a glance, with its wheel handle, the conditions of supply, that is, whether it is turned on or off; (5) the metal composition should give the cock sufficient strength to withstand hard usage, and should be such as to allow the component parts to be machined efficiently during the process of manufacture.

Figures 194 and 195 illustrate gas cocks of the above design. The former has a wooden handle and is used for top and oven range burners, and also for burners of hot plates, laundry stoves

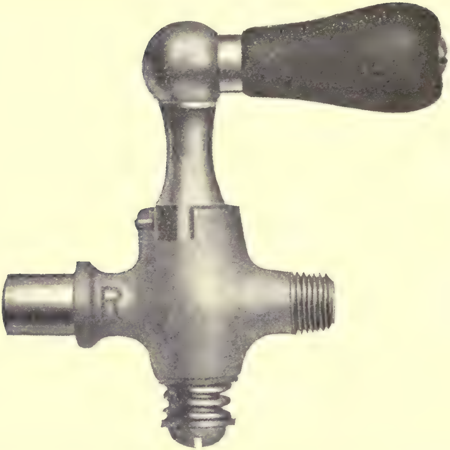


Figure 194.—Range Cock, wooden handle, page 679.

and other miscellaneous appliances. Porcelain may be substituted for the wood. Figure 195 shows a metal handle; this has a definite use on an oven pilot burner, to differentiate sharply this burner from the oven burner itself and thus decrease the chance of inadvertently turning on the latter instead of the pilot burner. In both of these illustrations, the ring nut shown at the base of the plug in Figure 193 is replaced by a tail screw. The latter is an earlier development, but is not as satisfactory as the nut, because of greater difficulty, when the cock is in service, of separating the parts for inspection or adjustment.

In describing the general principles of the burner, it was stated that the rate of flow of the gas was regulated by the orifice in the cock, and that of the air by the opening through the air shutter. The regulation of the latter has been explained, but nothing has been said about the orifice or "spud." It shows in Figure 193 as the hexagon projection on the extreme left of the cock. A detail drawing is given in Figure 196. The size of the gasway through the spud varies inversely with the square root

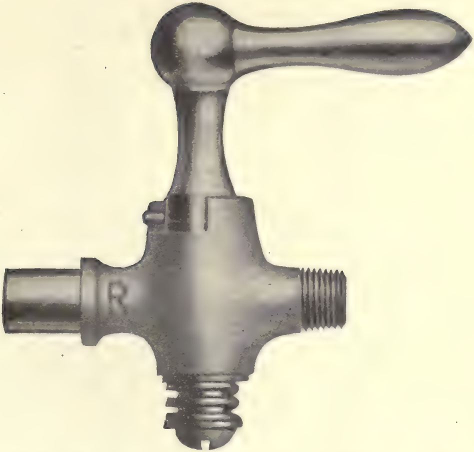


Figure 195.—Range Cock, metal handle, page 679.

of the gas pressure, and in Figure 197 is given a table of pressures and diameters usually followed.

When for any reason an increase in size of gasway is desired, this may be done either by substituting another spud of the correct gas way, or, more usually, by reaming out the opening in the

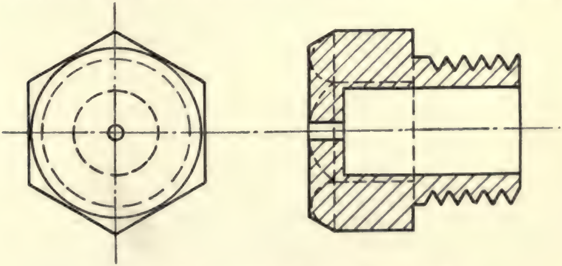


Figure 196.—Orifice or Spud, page 680.

ORIFICE SIZES GIVEN IN MORSE TWIST DRILL GAUGE
AND FRACTIONAL PARTS OF AN INCH
CONSUMPTIONS PER HOUR FROM 2.5 CU.FT TO 92.5 CU.FT AT PRESSURES FROM $\frac{5^{THS}}{10}$ TO $\frac{60^{THS}}{10}$

PRESSURE TENTHS OF INCHES OF WATER	CU.FT OF GAS PER HOUR																																					PRESSURE TENTHS OF INCHES OF WATER
	2.5	5	7.5	10	12.5	15	17.5	20	22.5	25	27.5	30	32.5	35	37.5	40	42.5	45	47.5	50	52.5	55	57.5	60	62.5	65	67.5	70	72.5	75	77.5	80	82.5	85	87.5	90	92.5	
5	54	48	42	37	32	30	26	22	18	13																												5
10	56	1/16	48	44	40	36	32	1/8	29	28	24	21	18	13																								10
15	59	53	50	47	43	41	37	34	32	1/8	29	28	25	23	21	18	16	3/16																				15
20	60	55	1/16	49	45	43	41	37	35	32	1/8	30	29	28	26	23	21	19	17	14	3/16																	20
25	60	55	53	49	5/64	45	42	41	37	7/64	32	31	30	29	29	27	26	23	21	20	17	15	13															25
30	60	3/64	53	51	48	45	44	42	40	37	35	32	31	1/8	30	29	28	27	24	5/32	21	19	11/64	15	13													30
35	1/32	56	53	1/16	49	47	45	43	42	40	36	35	33	31	1/8	30	29	29	27	26	24	22	20	19	16	15	14											35
40	1/32	57	55	1/16	49	5/64	45	44	42	41	39	36	35	32	31	1/8	30	29	29	28	26	26	5/32	21	20	18	16	15	13	3/16								40
45	1/32	58	55	53	50	49	47	45	43	42	41	37	36	35	32	31	1/8	30	29	29	28	27	26	24	5/32	21	19	11/64	16	14	3/16							45
50	1/32	59	55	53	50	49	5/64	45	43	42	3/32	40	37	7/64	35	32	31	1/8	30	29	29	28	27	26	24	23	21	20	11/64	16	15	14	13					50
55	1/32	60	55	53	1/16	49	5/64	47	44	42	3/32	41	38	36	7/64	34	32	31	1/8	30	29	29	28	27	26	25	5/32	21	21	19	17	16	14	13	3/16			55
60	1/32	60	55	53	1/16	49	48	47	45	44	42	41	40	37	36	35	34	32	1/8	1/8	30	29	29	29	27	26	24	23	22	21	19	18	16	15	14	13	3/16	60

NOTE:- THE ABOVE NUMBERS GIVE SIZE OF ORIFICE WITH ORIFICE SPUD FITTED IN ORDINARY GAS RANGE COCK ($\frac{3}{16}$" BORE).

Figure 197.—Table of Orifice Sizes in Cock Spuds, page 681.

existing spud. If the opening is to be reduced, it sometimes may be hammered to a smaller opening, but it is better practice to use another spud.

The cocks for the large appliances used in restaurants or hotels should be designed along the same general lines as those already described, but should be of greater strength to withstand hard usage. They are sometimes fitted with spuds having adjustable orifices to enable a rapid change in gas adjustment.

Figure 198.—Top Burner, page 683: A, Air Shutter; B, Mixer; C, Burner Tube; D, Burner Head; E, Drilled Ports.

Top Burners

A top burner is one supplying heat for the cooking top of the appliance, and is used for boiling, frying and miscellaneous cooking. One form is illustrated in Figure 198. A one-piece burner casting is standard, because the absence of joints results in the following advantages: Ability to clean the burner thoroughly by boiling without subsequent joint remaking; a smooth passage from the mixer to the ports, thus facilitating the desirable good admixture of air and gas; no disturbance of a proper air adjustment by leaky joints developing in service.

During the development stage, top burners were made in a variety of shapes, the two most common being the star and the ring, A and B, Figure 199. The former is now the accepted type, as it is quite flexible in its range of consumption, and its construction insures the prime requisite of any burner, i. e., good combustion, since a proper supply of secondary air is provided through the central air well and the spaces between the radial arms.

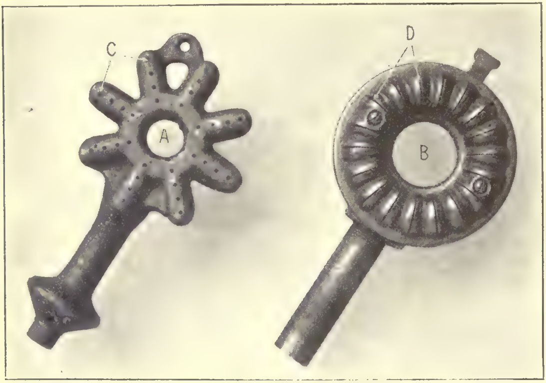


Figure 199.—A, Star Burner, page 684: B, Ring Burner; C, Drilled Opening; D, Sawed Opening.

The openings or ports in the burner head have also afforded an opportunity for different treatment, but they have always been either drilled, C, or sawed, D. There is no choice between the two as to efficiency of combustion, but the drilled burner is more serviceable, as its ports are more easily cleaned and they are not affected should the burner be warped by the heat.

A top burner should be so located below the cooking top as to allow a space of at least $1\frac{1}{4}$ inches between the top of the burner and the bottom of a utensil placed on the top grate. With less space the products of combustion will not be carried off freely, but will back down over the flame, thus obstructing the influx of secondary air and producing a tendency in the flame to smother.

Spaces of $1\frac{3}{8}$ and $1\frac{1}{2}$ inches are preferable, as they insure good combustion even with a high gas pressure.

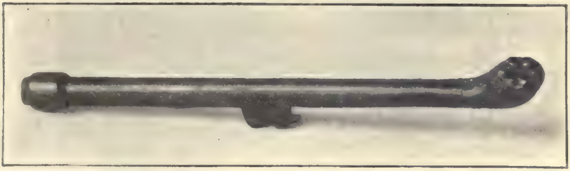


Figure 200.—Simmering Burner, page 685.

The ordinary top burner consumes 12 cubic feet per hour. The "giant" burner, usually included as one of the four top burners of the standard range equipment, consumes 18 cubic feet. It is useful where a large mass needs rapid heating. At the other end of the scale in so far as consumption is concerned, is a simmering burner, Figure 200. This has six ports and consumes 4 cubic feet per hour. It is used for any purpose that requires only a slow rate of heating, such as slow cooking, warming, and maintaining at the boiling point the contents of a vessel previously heated over another burner.

From the preceding description and illustrations, it is apparent that the modern top burner may be removed and replaced with ease, rendering its cleaning a very simple matter.

Figure 201.—Oven Burner, page 685.

Oven Burners

The oven burner, Figure 201, is used for baking, broiling and roasting, and in basic design is a steel or cast-iron pipe, drilled for its full length with either a single or a double line of ports. An essential feature of its construction is a provision to insure the correct position of its burner ports. For instance, if

the range design calls for downward projecting flames, as illustrated, any chance of the burner being placed with ports upward is prevented by casting, as part of the mixer, a slot or lug, which must engage with a reciprocal construction on the oven-burner plate before the burner can be put in place.

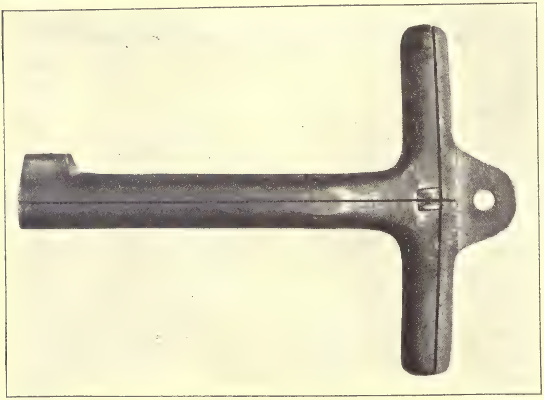


Figure 202.—Oven Pilot Burner, page 686.

To the ignition of the oven burner, much thought has been given. The top burner is in full sight, and if it fails to light, the fact is known at once. Also, any unburnt gas is not confined, but escapes freely into the room. The oven burner, on the other hand, is out of sight when the oven door is closed, and a very small amount of gas will form an explosive mixture with the air in the oven. Therefore, it is quite important that the lighting of an oven burner be easy and certain, and the fact of lighting or nonlighting be very evident at once. The commonest method employs a pilot burner of some kind, with its own cock. This burner is often located alongside the oven burners, being lighted outside the range. Figure 202 shows such a burner of T-shaped form. Figure 203 illustrates its relation to the range and the oven burner. The mixer is in the base of the T, and the ports

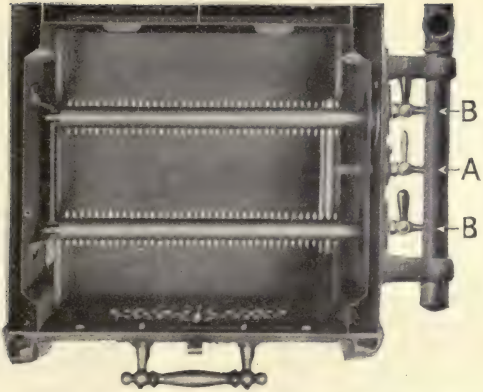


Figure 203—View of Range Showing Pilot (A) and Oven (B) Burners, page 686.

are drilled in the arms and in the leg also. With this type, the precautions taken to insure the proper lighting of the oven burners are as follows: First, the pilot cock has a distinctive handle, so that the sense of touch is an aid in always lighting the pilot burner first; second, there are a few ports in that part of the burner outside the range, so that sight tells whether or not the pilot burner is lighted before the oven burner cock is open. In addition to these, there is the universal precaution that applies to all oven lighting, viz., to open the oven door before starting to light, and to keep it open until it is certain that the burners are lighted. Not until this is known should the pilot burner be shut off. Another type of pilot burner is located in the oven itself, and to light it, the oven door must be opened. This is an advantage in compelling such door opening before any lighting can be accomplished, but the lighting is sometimes not as conveniently done as by the outside pilot.

Some oven burners are lighted by means of a trough-shaped casting which conveys the gas from the burner to the lighter opening in the bottom of the oven. Others have no separate lighter but are ignited direct.

Special Burners

A single-port burner, A, Figure 207, with a long vertical mixer, is used on many "heavy duty" hotel ranges and on some hotel broilers. It delivers, horizontally, a long bunsen flame, of volume sufficient to heat a large area. It is misnamed a "siphon-blast" burner.

A burner of comparatively recent design, developing heat in a radiant form, is used effectively for broiling on hotel appliances, and is known as the "surface combustion" burner. It was designed to obtain a higher temperature, and consequently a higher efficiency, than is possible with the ordinary bunsen burner, and also to avoid any provision of secondary air, the requirements for which provision, in many cases, restricts greatly the application of a burner. All the air required for complete combustion is mixed with the gas before it reaches the burner, to which the mixture is forced through very small tubes, at a velocity greater than the speed at which an explosive flame could travel backward. Just beyond the outlet of the tubes is placed a strip, or series of strips, of metal having a very high fusing point. These strips act as a sort of baffle, and confine the combustion of the gas to the space between the face of the burner and the metal strips. After the burner has been lighted for a few minutes, the metal strips become incandescent, and no flame is visible. A large portion of the heat generated is thus available in radiant form.

This system requires a forced supply of air at about the same pressure as the gas, and a regulation to maintain a constant mixture with the same position of a mixing valve, the adjustment of which enables any necessary change in air supply to suit a change in gas composition.

Cooking Tops

Having considered the burners found in an appliance, we pass to their arrangement and their relation to the structure of the appliance itself. For top burners, the cooking tops vary from the single burner hot plate, Figure 204, to the many burners of the most elaborate cabinet range, but the commonest equipment is shown in Figure 205, the top view of a domestic range of either the double-or single-oven type. On single-oven ranges, the simmering burner is often omitted.

The supply line, in which each cock is screwed, is called the manifold, or burner rail, E, and is made of steel of extra heavy thickness to afford additional thread surface. It is

Fig. 204.—Single-Burner Hot Plate, page 688.

attached to the range top by split brackets, F, allowing a quick replacement. On new ranges, the burner rail is now being tapped with an extra hole for the subsequent connection of any "burner lighter." This, Figure 206, is installed with its burner head in the centre of the cooking top. By pressing the button, a jet of flame is sent from the continuously burning pilot light to each of the four burners.

In each side of the main top or frame, G, Figure 205, there are two slots, which, engaging with the projecting lugs of a side shelf, provide for the latter a firm support and yet allow of its quick removal. These shelves, H, are either solid castings or gratings.

The grates, J, are usually made in two castings, and are interchangeable. The standard design has radial arms as shown, extending into the spaces between the burner arms but not directly over the latter. Occasionally the arms of the grate are parallel, to allow for small utensils. The top of the grate surface is $\frac{3}{16}$-inch above that of the top frame, to facilitate the supply of air to the burners.

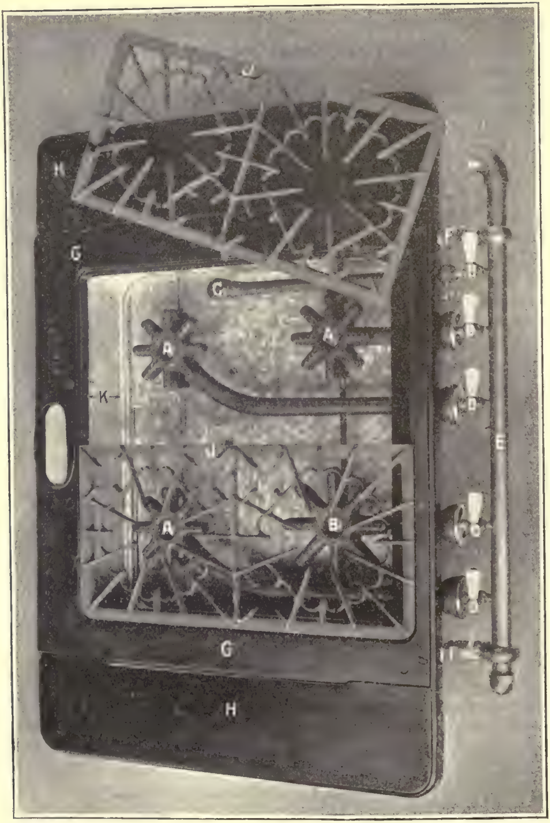


Figure 205.—Top View of Domestic Range, page 688: A, Ordinary Burner; B, Giant Burner; C, Simmering Burner; D, Cocks. E, Burner Rail; F, Burner Rail Supports; G, Main Top; H, Side Shelves; J, Burner Grates; K, Burner Box; L, Drip Pan.

The burner box, K, is of sheet steel, galvanized to resist corrosion, and of one piece for easy replacement. A loose drip pan, L, of galvanized or enameled iron, serves as a catchall and as a protection to the bottom of the burner box.

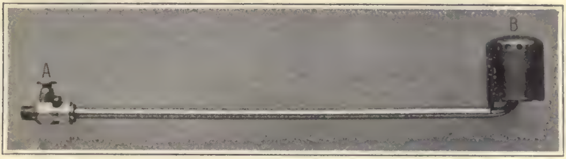


Figure 206.—Burner Lighter, page 689: A, Button; B, Burner Head.

Leaving the domestic range and turning to the appliances used in hotels and restaurants, we find a different type of top: The "all-hot" top implies, as its name indicates, a solid surface uniformly heated. It is made of heavy cast steel, supported on channels in the side frames. Independently controlled, single-port burners are used, A, Figure 207. There is a combustion chamber, B, of shallow height, but extending the full width and depth of each hotel range section. It is insulated from the oven beneath by asbestos board, on which is placed firebrick. The latter absorbs heat from the flame passing above it, and by its reflection materially assists the direct heat from the flame in maintaining the top at a working temperature. The combustion chamber is divided by a solid partition into front and rear halves. Each half is heated by its own burners—usually three—and may be worked alone without much loss of heat to the idle portion.

Across the combustion chamber from the burner port is a cross outlet flue, C. When the burners are first lighted, a sliding top 3 inches shorter than the flue, is pulled forward by a handle at the range front. This provides an opening in the cross flue, at the main flue, for the direct escape of the combustion products, and soon produces a warm chimney and a good draft. Then the top is pushed back. This transfers the opening in the cross flue to the range front. Therefore, the products are forced to come forward and then travel backward in the cross flue. During this increased travel, heat is transferred to the surrounding surfaces and the efficiency of the range thereby increased.

This form of top is economical in "heavy duty" cooking, that is, the preparation of food in large quantities and at regular intervals, as in institutions or hotels and restaurants either on the American plan or serving *table d'hote* meals. For "short (or quick) order" work, it should be equipped at one end or between two sections, with star top burners under the usual grid top, or else the work should be done on the range shown in Figure 208.

The hot top construction has gradually displaced for "heavy duty" work, a semiclosed top range, which had one star burner with open grating in each section, the remainder of the top being solid and heated by drilled pipe burners.

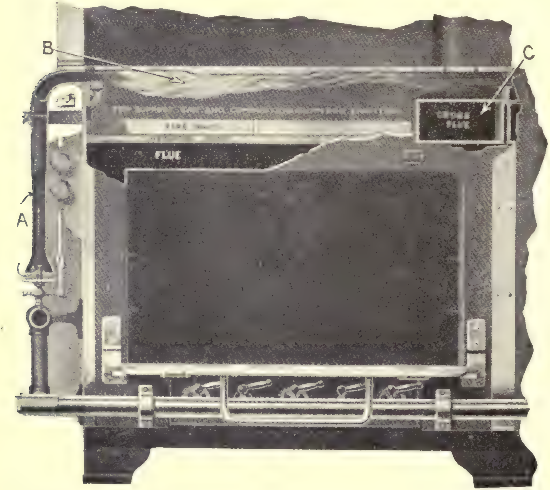


Figure 207—All-Hot Range Top, page 691: A, Burner; B, Combustion Chamber; C, Outlet Flue.

Figure 208 illustrates a range top extensively used for quick order work. It resembles the ordinary domestic top, but is

larger, with more burners and those of greater capacity. Either open or semiclosed grates are used.

Figure 208.—Open Top Hotel Range, page 692.

Figure 209 is a special top for small restaurants or quick order work. As each section is interchangeable, any arrangement of burners and top grates can be provided.

OVENS

GENERAL

To the gas oven, not only in the method of igniting its burners, but also in its design and construction as a whole, much thought

has been given. The faults of early forms tended to confirm a popular prejudice that uniform cooking or baking by gas was not attainable, and only time itself could put an end to the unfounded but long-held belief that anything cooked in a gas

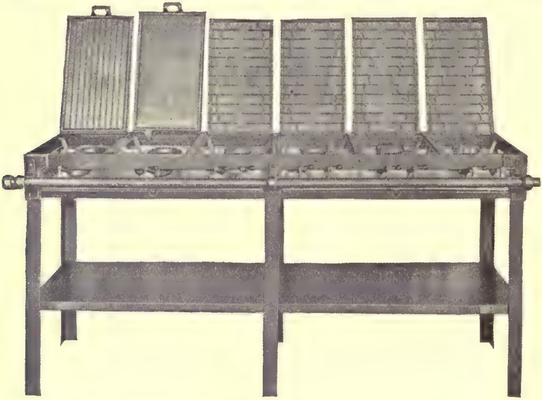


Figure 209.—Special Top Restaurant Appliance, page 693.

oven tasted of the fuel. Due to the intelligence and perseverance of the range makers and gas companies, the course of range development and public education did not flag, until now in millions of homes the gas range is established, and though its improvement continues, its value needs no more proving.

Ovens may be classified according to construction into general types, as follows:

1. Direct-action: Burner within oven and no intervening baffle plate.

2. Semidirect-action: Burner under oven bottom or baffle plate with circulating flues.

In a direct-action oven, in order to prevent too much concentration of heat on the articles to be cooked, the burner is a U-shaped pipe, placed at the bottom, extending around the two sides and the front. The flame ascends from ports drilled vertically in the pipe top. Such a burner cannot be used for broiling, and, therefore, is found only in a single-oven range.

A baffle plate over the burner just described converts the oven to the semidirect type. Usually, though, in this type the burners are straight cast-iron pipe, running from side to side.

Because of its greater efficiency, the oven with a semidirect-action burner and circulating flues, is the standard type today. Though construction details may vary in different makes, the

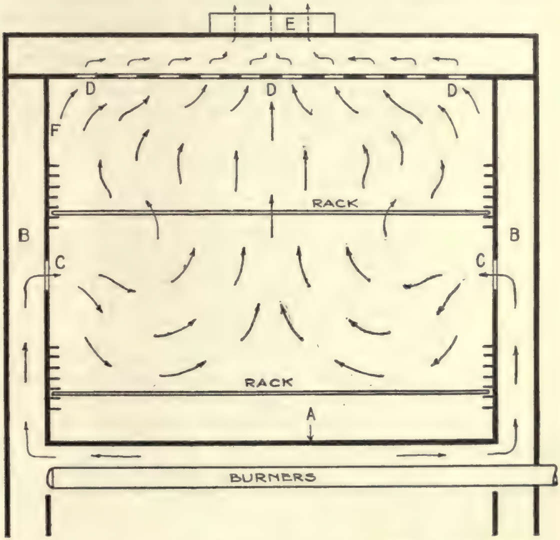


Figure 210.—Section of Oven Showing Circulating Flues, page 695: A, Oven Bottom; B, Side Flue Space; C, Openings into Oven; D, Vents; E, Flue Outlet; F, Linings.

essential points are alike in all ranges. These are shown in Figure 210, as follows: A, an oven bottom properly insulated, either by air space, as here shown, or by sheet asbestos, from the direct heat of the burners; B, side flue spaces, through which rise the combustion products; C, openings from these spaces into the oven; D, other openings, called vents, in the top lining, or

occasionally in both top and back lining, to let out the combustion products on their way to E, the flue outlet.

The illustration shows a completely lined oven. In such the back would be lined also. The doors would be insulated by the use of two metal sheets, with either asbestos or air space between them. A cheaper form of construction would omit the linings, and the door would be of solid cast iron, preferably coated on the inside with aluminum bronze to increase the amount of reflected heat.

The door is of either the "swing" or "drop" type. In the former case, it moves in a horizontal plane on vertical hinges. In the latter, the hinges are at the bottom and the door drops from a shut to an open position, being counterbalanced by springs (preferably) or by weights, to remain in any position. A positive catch, which locks when door is shut, is not permissible, as the door must be free to open in case of an explosion within the oven.

Flue collars are constructed with uneven edges, to prevent the complete closing of a flue, either by the placing of some article on a horizontal end or by the too close proximity of a vertical end to a wall. This is also true of water heaters and all other appliances designed for a flue connection.

As compared with the ordinary domestic range, the oven of a hotel range is larger in size and constructed of heavier metal to withstand the more severe usage to which it is put. In the "universal control" type of the all-hot top range, the top and ovens are heated by the same burners, and, therefore, this range will prove economical where the cooking to be done is of such kind and quantity that there is use at all times for every part of the range.

Baking

The ordinary baking oven differs only in a few details from the construction already described. It usually has two racks, for which four heights in all are provided by supports, on which the racks slide freely in and out, and which, by their channeled construction, keep the racks from tilting even when projecting outside the oven.

A glass panel is sometimes inserted in the oven door to afford sight of the food without the chilling which accompanies any door opening. An oven thermometer is also added to enable closer heat regulation.

For baking on a large scale, one of the most successful appliances employs revolving shelves surrounded by an insulated metal oven. The heat is supplied by pipe burners located in the oven bottom. The heated products are well distributed by a

Figure 211.—Double-Oven Range, page 699.

perforated baffle plate above the burners, and the currents produced by the motion of the revolving shelves maintains an even heat circulation throughout the oven. Where the amount of work is too small to justify this appliance, a type with stationary shelves is used. The heat circulation is such that a current is maintained between each set of shelves. A near approach to

uniform heating is attained, the variation being that the ends of each shelf, at which points the products are admitted from the side linings, are slightly hotter than the middle, involving one shift in position during baking.

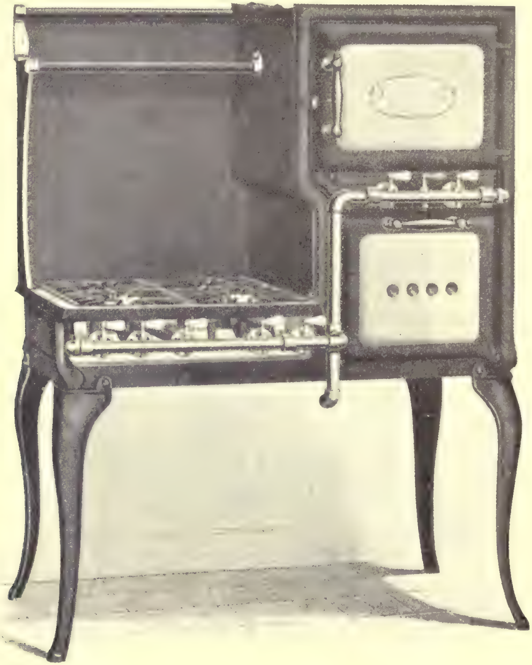


Figure 212.—Cabinet Range, page 699.

BROILING

Generally, the broiling oven of a domestic range is placed directly beneath the baking oven to make the burners that serve for baking purposes answer also for broiling. Examples of this

are the ordinary double-oven ranges, Figure 211, and the simple cabinet, Figure 212, and elevated double-oven ranges. In some of the earlier forms of the ordinary double-oven ranges, the broiling oven was placed for convenience over the baking oven, but as this arrangement required two sets of burners, it never became popular. There are some present indications, however, that the design may be revived.

In the broiling oven, the burners are at the top, with the flames projected downward at an angle. The cooking is done by the radiant heat from these flames and from the oven top just above them. To increase the amount of radiation, a cast-iron grid is sometimes placed over the burners to absorb and radiate heat which otherwise would go by convection to the baking oven above. In the double-oven range, the oven bottom is generally constructed of two sheets of metal, separated by an air space to protect the floor from too high a temperature. For this same reason the top sheet of the oven bottom is blackened and the bottom one is galvanized, to reflect the radiant heat passing through the top sheet.

The secondary air for combustion is usually admitted through slots or perforations in the broiling oven bottom, and is conducted to the burners through the space formed between the rack supports and the adjacent side linings of the oven. The rack supports are placed as close together as possible to give any desired distance of the broiling pan below the burners. Sometimes the broiling oven is placed on a level with the cooking top, in order that the convected heat of the broiling burner may be utilized for top cooking.

In hotels and restaurants, the broiling is usually done on separate appliances especially designed for the work required. One of these has three single-port burners, the flames passing directly above the meat pan. A refractory surface above the flames increases the heat available for cooking.

A combination broiler and griddle of heavy construction, shown in Figure 213, is extensively used in restaurants. The heated air from the drilled pipe burners passes through slots in a baffle plate, and then is evenly distributed through a series of holes in a plate just below the top plate. This latter is of polished cast iron, and is serviceable for broiling, toasting, or making griddle cakes.

Insulated

In the baking and broiling ovens of the ordinary range, no attempt is made to conserve the heat in the oven by decreasing

the radiation from the outside body; that is, by the installation of insulating material such as asbestos. The insulated oven range is the result of an attempt to conserve the heat which is ordinarily lost by radiation. However, inasmuch as the ordinary oven is of the circulating type, and the heat, after circulating through the oven, passes almost immediately into the outside air, little is to be gained by the installation of insulating material about the oven sides and doors. In certain instances, to overcome this difficulty, the type of oven has been changed; that is, the oven is made of the direct-action type. In certain other

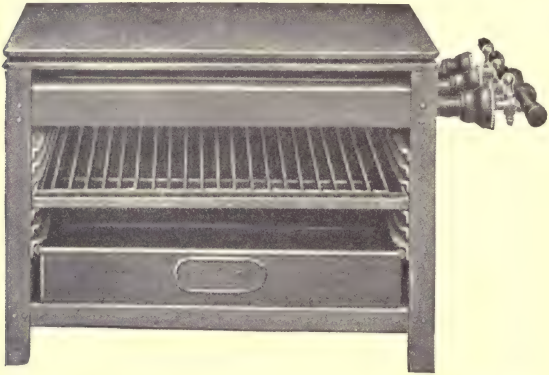


Figure 213.—Combination Broiler and Griddle, page 699.

instances, soapstone heat retainers have been placed in the oven bottom, and the range is then supposed to be used in a manner similar to the well-known fireless cooker devices. In one particular range, a device is attached to the oven burner which may be set to turn the gas off automatically at any predetermined time. Articles to be cooked are placed in the oven, the timing device set, the burner lighted, and the articles are supposed to be cooked, partially by the direct heat of the burner, and the cooking finished by the heat given off by the soapstone slabs after the oven burner has been turned off by the automatic timing device.

There is no doubt that some economy in the use of gas may be effected by the use of insulated oven ranges and similar ovens equipped with automatic timing devices, but since this addition results in an increased cost which is hardly commensurate with the possible saving to be made, they have not had a widespread use.

Entire Appliances

The preceding descriptions and illustrations of the essential parts of a cooking appliance, and especially Figures 205, 211 and 212, have probably made clear the basic features of the construction and operation of such appliances. It is clear that the gas range—except for the burners and cocks—is really a framework upon which are built up sheet iron parts. This framework may be either cast iron or steel. Some manufacturers prefer the former and some the latter, but as long as the framework possesses sufficient strength to resist breakage, there is little to choose between them. From the manufacturing standpoint, however, the steel framework construction is the more expensive.

The body of the gas range and the oven sides, tops and bottoms are made of sheet iron, and are put together so as to be readily removable. The outside body of the range is usually coated with japan or enamel to resist corrosion. When it is known that ranges are apt to be subjected to hard usage, cast-iron bodies have been used successfully.

The over-all dimensions of some standard forms of appliances are given below:

Type	Length	Breadth	Height
One-Burner Hot Plate	$12\frac{1}{2}''$	$12\frac{1}{2}''$	7 "
Two- " " "	$22\frac{1}{2}''$	$12\frac{1}{2}''$	7 "
Single-Oven Range	$36\frac{1}{2}''$	25 "	$31\frac{1}{2}''$
Double- " "	$36\frac{1}{2}''$	25 "	35 "
Cabinet "	$52\frac{1}{2}''$	25 "	50 "

Conditions of Use

Circumstances of Consumer

The first element which is considered by the purchaser of any appliance is, naturally, its cost. This, however, is not necessarily the deciding factor, as the character of the work demanded and the space available—topics which will be touched upon later—often receive close attention.

Cheap as well as expensive appliances are to be found, just as cheap and expensive commodities are to be had in other commercial lines. The expensive appliance is generally more satisfactory in all respects than the cheaper article, but it would be injudicious to ignore the latter. As an illustration, the situation in some of the New England towns may be cited where cookers, hot plates and portable ovens very often form the largest proportion of the appliances. The average millworker in these towns is either unable or unwilling to purchase the more expensive standard single-oven, double-oven or cabinet range, and consequently must find a substitute in a cooker or in a combination of a hot plate and a portable oven. A similar condition is found in the tenement districts of large cities.

Stepping up from the single-oven cooker and the combination of a hot plate and portable oven, the single-oven range is the next in line, but it could really be included in a general classification with the double-oven and cabinet ranges. These ranges meet the demands of the average consumer. In wealthier homes, triple-oven cabinets of a variety of designs, generally equipped with additional top burners, and also special ranges suitable for every conceivable purpose and adapted to every requirement for cooking, are to be found.

Of course, all styles of cabinet ranges can be equipped with the various additions of top shelves, warming closets, canopies, hoods, glass door panels, temperature indicators, enamel equipment, porcelain cock handles, and all the refinements which make for cleanliness and add to the appearance of the appliance. To meet the demand for ranges of higher quality, both as regards durability and attractiveness, manufacturers are supplying ranges with the sheet metal parts made of special rust-resisting material, or protecting these parts with an aluminum coating or some other preservative. The cast-iron parts are also frequently given a baked enamel or some other high-grade finish.

Space Available

The question of space, particularly in small apartments and residences, is a very important factor in the selection of a domestic appliance. For the small apartment, the elevated-oven type of range usually solves this problem, and also gives the necessary capacity, while in the small residences, short [illegible]binet and double-oven ranges are often the largest types that can be used.

Character of Work

Domestic Cooking

The domestic appliance is used principally for general cooking, with a certain amount of bread and other baking. In addition, the top burners are often used for laundry purposes. While, in a majority of cases, gas is still used as an auxiliary to coal for cooking purposes during the winter, yet in a large and rapidly increasing number of homes, the coal range has been banished.

Hotels and Restaurants

For small restaurants, the so-called "short order" work is the main feature to be considered in the installation of an appliance. Here usually is found a two- or three-burner oyster cooker, which will take care of the cooking of single stews, frying of chops, etc.; a broiler for steaks; a combination toaster and griddle; and perhaps one large burner, consuming from 50 to 60 cubic feet of gas per hour, for the deep grease frying, such as oysters, croquettes and doughnuts. For cooking that requires a longer time, such as the roasting of meats and the boiling of soups, a gas range is often installed and usually with a four-burner top and an 18-inch oven.

In hotels and large restaurants, the work is much heavier, and consists of the roasting of large joints of meat, cooking of vegetables, the boiling of large kettles of soup, and the baking of a various assortment of special foodstuffs. This requires hotel ranges of heavy construction and other specially adapted appliances. Quite a little broiling is done, and for this a special combination broiler and toaster, Figure 213, is installed, or perhaps the broiler is placed over the top burners of the hotel range as an elevated oven. The latter is more apt to be the case on account of the space limitations in kitchens of this type. Steam tables for keeping all the foodstuffs warm, stock pots, coffee urns and plate warmers would make up the rest of the kitchen equipment.

CHAPTER LXIII

CONNECTION PRACTICE

Preinspection for

Location of Appliance

Consumer's Wishes

When the first representative of the distribution department arrives on the premises, whether a preinspector or a fitter, he should interview the consumer and decide on the exact desired location of the appliance. The location of a cooking (as well as any other) appliance should be determined by the wishes of the consumer, except where safety and proper operating conditions interfere. In that case, the reasons for another location should be clearly explained to the consumer, but if he does not agree with the decision reached, the matter should be referred to the office for final disposition.

Where conditions are such that it is possible to make the connection in several ways, such as by iron pipe or by flexible tubing, or by a combination of both, the method proposed should be explained to the consumer, as should also be any necessity of breaking floor or walls, or the possible unsightliness resulting from running exposed pipe.

Minimum Fire Hazard

To avoid a fire hazard from the overheating of any adjacent structure, the following points should be observed:

> The combustion products should be prevented from impinging directly on any wood or other inflammable material. If the products are discharged in a horizontal direction, the discharge opening should be at least six inches from the surface in question. If a baffle is provided, or if the products are discharged vertically, a space of one inch between the top casting and the surface is considered sufficient.

When there is an oven at a higher level than the top burners, a minimum distance of four inches from the outside of the oven to a wall of inflammable material should be maintained, or some intermediate protection provided. One method of protection is by sheet asbestos one-eighth inch thick and covered with sheet iron or zinc of convenient gauge.

With a wood floor, the distance from the floor to the bottom oven lining of an ordinary domestic range should be not less than four inches, and any appliance having an unventilated base, or legs too short to afford the required distance, should not be connected. As protection to a wood floor, a base of cement, slate or hollow brick should be always provided when installing a hotel range or a combination coal and gas range.

Appearance and Ease of Connection

Preceding considerations not interfering, the safe location necessitating the smallest amount of connection labor and material should be chosen. The relation after installation of the appliance and its connections should be considered. In general, the appliance should be placed as close to the wall as possible, and should not project into or tend to block any passageway. However, the accessibility and easy manipulation of any parts of the appliance, especially burner cocks, should be assured. It should be possible also, with little trouble, to shut off any cock at the appliance, or to unscrew the long screw or union necessarv for disconnection.

Exposure

Exposure to damage from weather conditions, or to excessive draught, which may blow out the flame or deflect it from its natural position, sometimes may be determining location factors.

Condition of Appliance

After the location has been determined, the appliance should be inspected for completeness and for the condition and proper assembly of all its parts. If any are imperfect, and if the appliance has been purchased recently from the company, proper orders should be originated to have these parts made good. Should the appliance be old, or one not purchased from the company, any defect should be called to the attention of the

consumer and the latter advised as to its remedy. If the work can be done by the company, the consumer should be requested to sign the necessary order.

The inspection should also include an examination into any peculiar or unusual design. If the appliance is not of approved type, a detailed report of the peculiarities should be made to the office and the connection delayed until its desirability is passed on. However, if it is possible, by some slight change, to make the appliance conform to an approved design, this should be done and the installation completed.

Service

When the appliance to be installed is of a comparatively high consumption rate, or when there are indications that the existing service is already taxed nearly or quite to its capacity, the maximum probable consumption rate should be estimated by the use of proper data, and the required service size determined. Unless these computations show that the existing service is far under size, no enlargement should be made until the necessity for this has been proved by actual test after the installation.

Meter and Connection

The meter and its connections should be inspected to be assured that their capacity is in accordance with the schedules given in Chapter XLVIII. If inadequate, orders should be given to make any enlargements required.

As most domestic cooking appliances have a comparatively small rate of consumption, it will be seldom that the service, the meter or its connections will need renewing solely on account of insufficient size.

Appliance Line

If there is an independent line already available, it should be used, unless inspection shows it to be in bad condition, or so much smaller than the standard size that there is no reason to believe its carrying capacity will suffice. Where there is a large saving by the use of the existing line, the question of supply should be carefully computed and even experimentally determined before running any new piping.

If there is no independent line, the appliance may be connected to an outlet in the existing housepiping system, provided that this outlet is supplied by piping installed in accordance with the rules in Chapter LIII, that it is at least as large as the inlet

piping of the appliance to be connected and is not already supplying much gas to other appliances, and that the appliance is to be placed within 15 feet of the outlet. The connecting pipe should be the size of the outlet. These outlet connections are more generally available for small appliances such as hot plates.

With neither outlet nor independent lines available, a new line will be needed. Because of the great variation in consumption of cooking appliances of different types, it is impossible to make a schedule of standard pipe sizes for all kinds of appliances and lengths of run. However, a certain standardization has been reached in dwellings, containing, as they do, appliances of approximately equal consumption rate requiring lines of nearly similar length. Here good practice is to use 1-inch pipe for any horizontal and $\frac{3}{4}$-inch for any vertical line to a domestic range or to a range and water heater. For other appliances in dwellings or appliances elsewhere, the pipe size can be determined by a computer. The consumption rate is known and the length of the run. The available pressure drop will vary according to local conditions, but under normal circumstances 0.2 inch will be a good figure to use.

In order to save the trouble of computing the size in each individual case, the following table has been prepared. It is based on an approximate pressure loss of 0.2 inch through the maximum length and with the maximum delivery.

Pipe Capacities in Cubic Feet Per Hour for Various Lengths of Run

Length in feet	1 to 20	21 to 40	41 to 60	61 to 80	81 to 100
Cubic feet per hour	Size of Pipe	Size of Pipe	Size of Pipe	Size of Pipe	Size of Pipe
0 – 100	$\frac{3}{4}$"	1 "	1 "	1 "	1 "
101 – 150	1 "	1 "	1 "	1¼"	1¼"
151 – 200	1 "	1 "	1¼"	1¼"	1¼"
201 – 250	1 "	1¼"	1¼"	1¼"	1½"
251 – 300	1¼"	1¼"	1½"	1½"	1½"
301 – 350	1¼"	1¼"	1½"	1½"	1½"
351 – 400	1¼"	1½"	1½"	1½"	2 "
401 – 450	1¼"	1½"	1½"	2 "	2 "
451 – 500	1¼"	1½"	2 "	2 "	2 "
501 – 600	1½"	2 "	2 "	2 "	2 "
601 – 700	1½"	2 "	2 "	2 "	2 "
701 – 800	1½"	2 "	2 "	2 "	2½"
801 – 900	2 "	2 "	2 "	2½"	2½"
901 – 1000	2 "	2 "	2½"	2½"	2½"

Material and Tools

If the installation is being made under the "preinspection" system, the preinspector is the employee who obtains the information and makes the decisions and calculations previously mentioned. Under this system, his next duty is to make a list of the pipe, fittings and other material that will be needed in the installation, and then to notify the consumer that delivery of this material and of the appliance (if necessary) will follow. This notice is important to impress upon the consumer the desirability of not leaving home without providing access for the delivery wagon.

The list of material is turned over to the storeroom, the material is gotten together and the delivery made; this including, of course, the appliance when the latter is of the class kept in stock by the company.

Under other systems it is usual to deliver the material, the quantity of which has been standardized, and the appliance, shortly after the receipt of the order and without any previous visit of the preinspector. A variation of this scheme is practiced when the appliance is small and the connection work will not require much time. This consists of delivering the appliance on a wagon which is equipped with a stock of pipe and fittings sufficient to make connections of this type. The man in charge of the wagon is, of course, a practical fitter. This method is also used in connecting larger appliances when the appliance delivery has been made by the manufacturer or agent, or even the company, and the connection work will require only a small amount of material and labor. With these systems, the workman who made the connection would care for the work already described, and when working from a wagon, would list the pipe and fittings for the reimbursement of his wagon stock.

The tools used for the installation of cooking and other appliances are described in Chapter XX. See Figures 60 and 61.

Connection

Shutting Off Gas

Before starting connection work, the fitter should explain to the consumer that the gas must be shut off. If an immediate shut-off will cause great inconvenience, and the work involves running a line of fair length from the meter to the appliance, it may be advisable to do this before the gas is shut off, leaving the

pipe disconnected at both ends until the gas supply may be conveniently discontinued and the connection made. This, however, is not economical working and should not be followed unless absolutely necessary. It is not feasible when the appliance line already exists, or when the connection is to be made to an existing outlet in the housepiping. In such cases, the shut-off should be made at once and the piping started at the outlet and run toward the appliance.

Running Piping

It now should be definitely decided where the line, if one is needed, is to start, and its location. Unless prevented by conditions as stated above, or by other local conditions, this work should be started at the point from which the supply is to be furnished, usually at the meter or at an existing outlet, and continued to the appliance. It should be governed by the piping rules given in Chapter LIII. The following additional points may be noted:

> Avoid a location subjected to draughts, to excessive heat or cold, or to sudden temperature changes; one that will interfere with the operation of doors or windows, or diminish the headroom of a passageway or stairs; or one in a shaft or duct whether alone or in common with other structures. In general, the easiest run consistent with safety and good workmanship should be followed, but an unfavorable location should not be taken because it affords an easy installation.
>
> Run exposed piping preferably. If exposed where an unfinished appearance is objectionable, use galvanized material, or paint to conform with surroundings. If the piping crosses electric wires with a clearance of less than six inches, protect the wires with porcelain split sleeves.
>
> The line should be run parallel to the wall of the building or room. It should have a fall toward the meter, or when this is impossible, should be provided with drips at the low points. These should be so installed that condensation may be easily removed.
>
> Where there is a possibility that the line may be used to supply other appliances located along its length, all joints should be made with a tee instead of a socket.

The jointing material should be chosen with the idea of making a tight joint, but one that is not extremely hard to take apart.

In dwellings, except where a tubing connection is used, a cock on the line at the appliance is unnecessary, because the gas may be conveniently shut off by the meter cock. In restaurants, or other places where a number of appliances are in constant use, or where, for other reasons, the even temporary discontinuance of the gas supply is undesirable, a cock should be placed on the line at the appliance. The union or long screw used at this point should be placed between the cock and the appliance. Ebonite washers are recommended for use on these unions.

Proper swing joints should be placed at all appliances with burner rails, in order to allow easy adjustment for direction of burner cocks.

Turning On Gas

After the gas line has been installed, properly fastened in place, and connected to the appliance, the gas may be turned on if the consumer desires, whether or not a flue connection is to be made. The turn on of the gas should be made with care, the instructions given for this work being faithfully followed. (See Chapter XLIX.) The line and the appliance should be "gassed out" and all new work tested for leak by sense of smell and, if necessary, by the use of soapsuds.

Flue Connection

A flue connection to a gas-burning appliance is often desirable to convey from the room the products of combustion or of cooking, and thus to avoid any objectionable odor, or deposit of grease that otherwise might be thrown against the walls and ceiling by the products. A flue connection is many times not only desirable, but also absolutely necessary, to eliminate the danger resulting from an escape of unburned gas, of the products of uncompleted combustion into any room, or of the products of combustion into a small room. In general, a flue connection to an ordinary domestic range is unnecessary, even when equipped with a canopy, unless the amount of cooking done is abnormal, but it is very necessary on hotel ranges, bakers' ovens and other appliances of this type, especially when these appliances are located, as often is the case, in unventilated rooms in

the basement of the building. To some extent, a hotel range is dependent for its efficient operation on the chimney draught.

The foregoing principles lead to the adoption of the following requirements, which should be met by the company in all installations made by its employees, and insisted on in installations made by others before gas will be turned on or repair work done.

Flue connections are necessary to cooking appliances of the following kinds and under the following conditions:

Any appliance (except a domestic range) when the hourly gas consumption exceeds 40 cubic feet.

A hotel range.

A baker's oven.

Any other appliance when the previously mentioned principles require it.

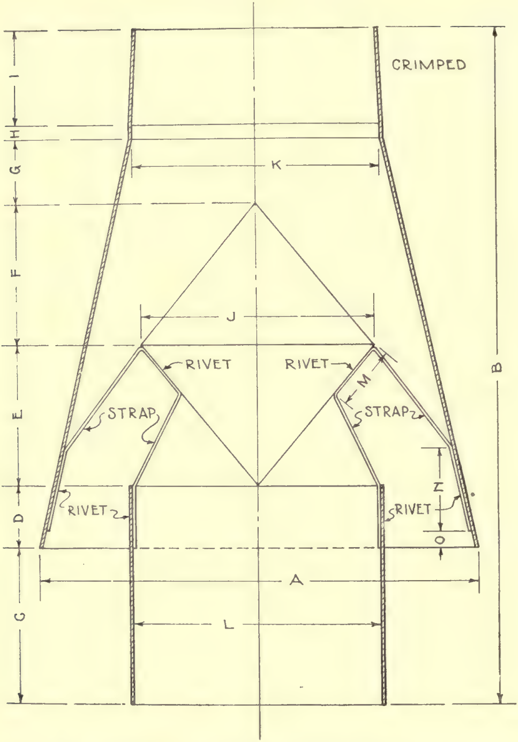
Before beginning work on an installation which requires a flue, the fitter should explain the location of the flue to the occupant, so that no question will arise as to the alleged unsightliness or the disfigurement caused by the flue connection.

It is preferable to have a separate flue or chimney for each appliance, but as this is seldom possible, each appliance should, if practicable, have an independent connection to the main flue or chimney. If this cannot be done, the new flue pipe may be connected into the flue pipe which already exists.

Blued steel flue pipe should be used inside of a building, where the location is not damp. Galvanized pipe should be used in damp locations, in cellars, and on the outside. No flue should be less than three inches in diameter. The following schedule shows the sizes for various kinds of cooking appliances:

Appliance	Size of Flue
Ordinary range	4"
Elevated oven range	4"
Cabinet range	4"
Canopy of range	Outlet Size
Hotel range	" "
Baker's oven	" "

A flue connection to any appliance, except a range provided with a canopy or its equivalent, should include a draft hood, Figure 214, which should be placed in the vertical run directly above the appli-



SIZE OF PIPE	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
3"	5"	$8\frac{3}{4}$"	$1\frac{3}{4}$"	1"	$1\frac{3}{4}$"	$1\frac{3}{4}$"	1"	$\frac{1}{4}$"	$1\frac{1}{4}$"	$2\frac{3}{4}$"	3"	3"	1"	1"	$\frac{1}{4}$"
4"	7"	$10\frac{3}{4}$"	$2\frac{1}{2}$"	1"	$2\frac{1}{4}$"	$2\frac{1}{4}$"	1"	$\frac{1}{4}$"	$1\frac{1}{2}$"	$3\frac{3}{4}$"	4"	4"	1"	$1\frac{1}{4}$"	$\frac{1}{4}$"

NOTE:- THREE SHEET STEEL STRAPS OF Nº 18 GAUGE (U.S.S.) $\frac{1}{2}$" WIDE AND PLACED 120° APART, TO BE USED FOR HOLDING DRAFT HOOD TOGETHER.

Figure 214.—Draft Hood, page 711.

ance. This hood is designed with a double cone baffle, which reduces the friction encountered by the ascending products of combustion, and at the same time prevents down draught from striking the burner flame.

When there is a side broiling or baking oven, or when two flue outlets are provided in a range having two ovens, pipe of the size of each outlet should be installed to a central Y fitting, and from there a 4-inch connection made.

Where there are more than two ovens, pipe of the outlet size should be installed; if there are two flue outlets, pipes the size of the outlets should be installed to a central Y fitting, and a 6-inch pipe run from that point.

When connecting two appliances, whether coal or gas, to one flue, it is desirable to have the area of the main flue equal to the combined areas of the flues from the two appliances. The flues should be joined as near as possible to the point where connection is made to the chimney.

The flue connection should be as short as possible, and long horizontal runs should be avoided. To accomplish this, the appliance should be placed close to where the flue connection would enter the main flue, or would pass out of the room. The flue pipe should be attached to the appliance by means of a nail slipped through the hole drilled in the cast-iron lip of the flue outlet. Horizontal runs should be slanted as much as possible, allowing a rise of at least one inch in three feet. The joints of such runs should be fastened to screw eyes in the ceiling above, with copper or malleable iron wire. When there are more than two lengths in any such run, the joints should be soldered or riveted together. Vertical runs ordinarily require no support except that given by their lower connection. When this is insufficient, they may be made fast in the same way as horizontal runs. A tee, with a capped end looking down, should be placed on the lower end of every vertical run. This serves as a trap for any dirt or moisture that may drop.

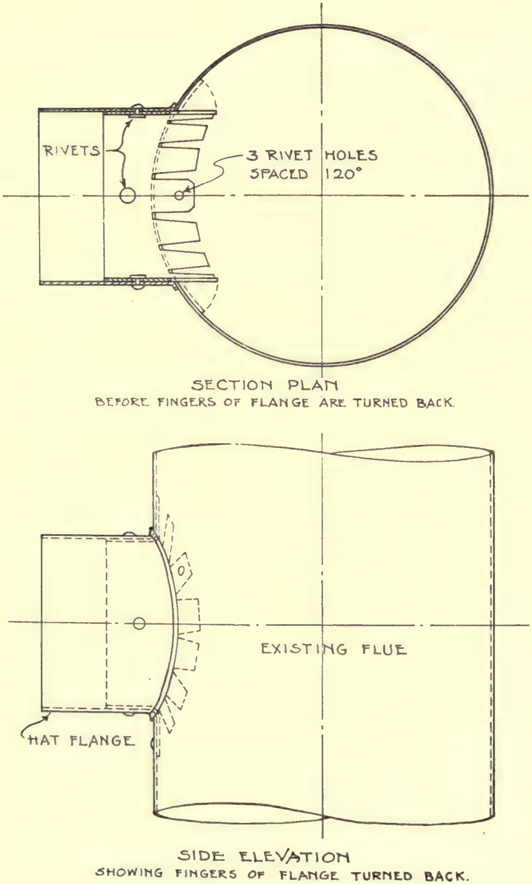


Figure 215.—Hat Flange, page 716.

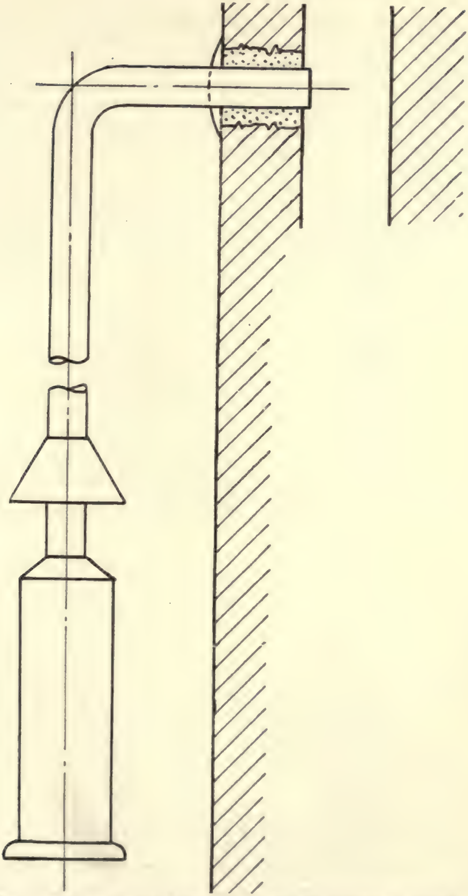


Figure 216.—Flue Connection to Ordinary Chimney,
page 718.

The connection into an existing flue pipe should be made by inserting a Y fitting, or sometimes a tee. Another connecting device is used, made on the same principle as the hat flange connection to a street main. A hole is cut in the existing pipe and the hat flange, Figure 215, inserted and fastened by bending over the numerous thin metal lips with which the circumference is provided.

The connection into a brick or masonry chimney is made by cutting out a hole of the proper size, Figure 216, inserting the flue pipe and making the opening tight again with plaster or cement. When making such connections, care should be exercised not to

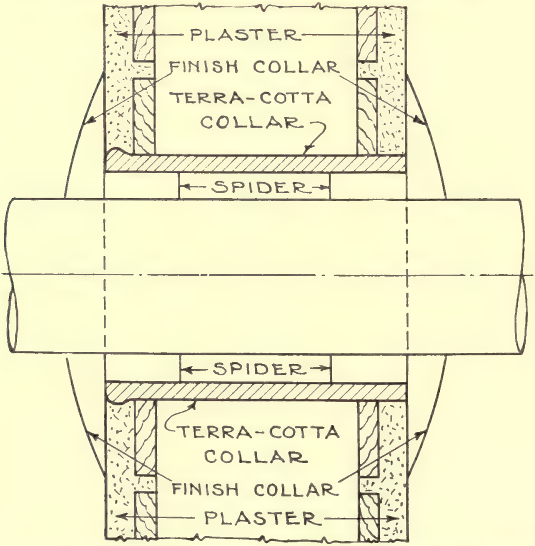


Figure 217.—Flue Connection through Lath and Plaster, page 718.

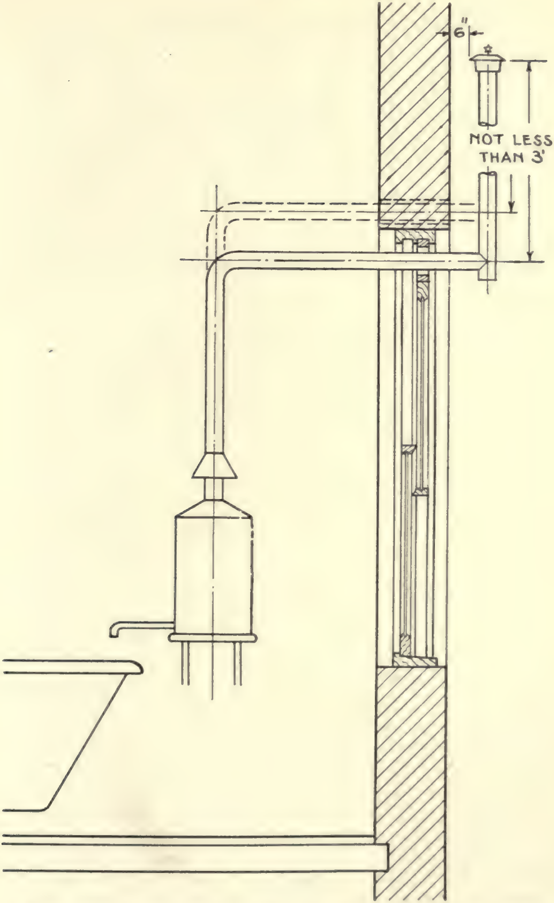


Figure 218.—Flue Connection to Outside Wall, page 718.

project the flue pipe into the chimney so far as to affect the draught by reducing the effective area of the chimney.

When it is necessary to run a flue through a partition of combustible material, such as lath and plaster, the hole should be cut large enough to insert a terra cotta collar of inside diameter 1 inch larger than the flue pipe. This is shown in Figure 217. The ends of the collar should be flush with the sides of the partition. The pipe should be held central in the collar by a "spider" or by corrugated tape about 2 inches wide. A finishing collar should be placed around the pipe on each side of the partition and flush against the latter. When there is no main flue or chimney available inside, the flue connection should be extended through the building wall to the outside, Figure 218. If this wall is constructed of combustible material, the method just described for an interior partition should be followed. If of masonry, a neat hole should be cut, a collar of some sort preferably inserted, and the flue run through this. If the occupant objects to cutting the outside wall, the extension may be made through a window unless it interferes with the closing of fire shutters. This can be done by either of the following methods: First, supply a board as long as the window is wide, so that it will fit snugly in the window frame above the upper sash, and wide enough to allow 1 inch clearance on each side of the hole cut for the flue. Cut this hole 1 inch larger in diameter than the pipe, and keep the latter central by using a finishing collar of some sort on each side. Second, remove a pane of glass from the upper sash, and replace it with tin or sheet iron in which is cut a hole for the flue. In either case, screw the upper sash fast, and nail a block in the lower sash groove, to prevent the lower sash, when raised, from striking and breaking the pipe.

When running a flue outside of a building and parallel to the wall, the length of the vertical outside pipe should be not less than 3 feet nor more than 10. Place the flue so that the inside edge of the standard cap is at least 6 inches from the wall, to prevent back draughts when the wind is blowing against the wall.

The flue should be firmly secured to the wall with braces.

After completing any flue connection, the appliance should be lighted to see that the products of combustion are being carried away by the flue. The consumer should be advised of the purpose of the flue connection, and warned that closing off or removing the flue will cause an unpleasant odor, or even more serious results in the case of a small room and a "blue flame" appliance.

It is not good practice to install a damper in a flue connection to a gas-burning appliance, unless it is found that the absence of the damper interferes with the draught of another appliance, or the consumer complains that its opening permits the entrance of insects or cold air, or the exit of warm air. Under these conditions, there should be installed a damper, in the centre of which is a hole 1 inch in diameter. This 1-inch hole is not always sufficient for flues from automatic water heaters, and in these cases, the area that cannot be closed should be supplemented by using a damper 1 inch smaller in diameter than the flue pipe, thus providing a half inch annular space between the flue pipe and the damper.

Inspection

After all connections necessary have been completed, the workman should carefully inspect each section of the installation and correct any fault found.

Adjustment and Instruction

If the workman's orders include a final adjustment of the kind of appliance just connected, this should be done now. This adjustment consists principally in a proper regulation of the supply of gas and air to the burner and mixer, and of an examination to make sure that all parts are in place and functioning correctly. When the appliance is of a type that the workman has been instructed not to adjust, he should explain that another man will follow for that purpose, and should advise the consumer that the appliance cannot be used properly until after a final adjustment. Under either condition, the man who makes the final adjustment, and the fitter before him, if competent, should nstruct the consumer in the use and operation of the appliance,

particular attention being given to the method of lighting the oven burners.

Records of Work

All records required for the work should be made. The work order should be posted with any necessary information, the lists of material used filled out, and an order originated for any further work required.

Cleaning Up

The workman should clean up any dirt for which his work is responsible, replace any articles moved, and notify the consumer either that the job is entirely complete or that another call will be made.

Subinspection for

Quality of Work

When the fitter who makes the connection is not considered competent to make the final adjustments and to give the necessary instructions, an inspection should be made by a qualified man known as the subinspector, within a short time after the installation. Such inspection should be made of the installations of all appliances having ovens, and of all extra large and special appliances, and those of new or unusual type. The inspection should consist of an examination of the mechanical work of the connection to see if instal ation has been made according to the rules before mentioned.

Operation of Appliance

The subinspector should make certain that the appliance is left in proper adjustment. He is presumably the last representative of the distribution department who will call, and he should, therefore, also determine that the consumer is familiar with the use and operation of the appliance, and any instructions to be given, or needs to be cared for, should be the subject of his close attention at that time.

Satisfaction of Consumer

The subinspector should endeavor to settle all questions to the consumer's satisfaction, and if unable to do this, he should inform the consumer that further steps will be taken to assure complete mutual understanding. When these points have been definitely settled, the installation may be considered complete in all respects.

CHAPTER LXIV

MAINTENANCE ROUTINE

Reasons Necessitating Maintenance

The rules given in Chapter LXIII are designed not only to make the installation of an appliance satisfactory, but also to reduce to a minimum the necessity for, and, therefore, the cost of, maintenance visits. However, no appliance can remain in constant use without inspection and repairs, and, other things being equal, the appliance that is used the most frequently will need the most attention. The cooking appliance is the gas appliance most universally used, and so its maintenance necessitates considerable attention from the company. Although adjustments and repairs usually are rather easy to make, yet this work requires the services of a well-trained man, and should not be entrusted to any one who does not thoroughly understand the proper remedy for each condition he may meet.

Domestic Appliances

Adjustments

Visits to maintain domestic cooking appliances usually are the result of a request by the consumer for attention. The most common trouble is that of an improper adjustment of the air and gas mixture, which results in poor combustion and slow cooking. This may be due to a change in the condition of pressure since the burner was last adjusted, or to an attempt by the consumer himself to improve conditions, but far more often is it due simply to an accumulation of dirt and grease on the burner top, or in the gas orifice, or both. On many appliances it can be due to the air shutter slipping out of position, thereby closing or opening the air ports of the burner, but on the more modern ones, this is made practically impossible by the improved air shutter construction (see Figure 192).

When a complaint man finds the trouble caused by wrong adjustment, he should proceed to remedy it, remembering

always that the orifices, burners, burner ports and other openings through which gas or air passes, should be clean and clear. The top burners of a domestic cooking appliance should be adjusted to a medium hard flame, having a blue cone from one-quarter to three-eighths of an inch long. Usually the flame top should be not nearer than $1\frac{1}{4}$ inches to the top of the grate bars. The oven burners should be adjusted to a slightly longer and softer flame, and if the adjustment is made while the oven is cold, allowance should be made for the flame softening still further after it has been burning for a short time. Bearing these rules in mind, if the complaint man finds the flames yellow-tipped, indicating too great a proportion of gas in the mixture, he should investigate and find the cause of the trouble. If it is due to insufficient air being admitted through the air shutter, the latter should be opened. If due to an excess of gas, the orifice should be well hammered up and then reamed out to the proper size. If due to a gas pressure so low that insufficient air is being entrained into the mixture, the cause should be located and remedied. The cause of such poor supply may be a stoppage in the orifice or the burner cock, and this may be removed by a wire or a reamer, or it may be due to various other conditions of stoppage, small size, or other defect in the supply piping, the meter, the service or the main. In this event, it should be treated in accordance with the rules given under the appropriate headings in Chapters XXXIV and LVII. Dirty burners are always productive of trouble. They may be the result of grease and dirt entering the ports through a long period of time, to food boiling over, or to the flame flashing back and burning at the orifice and depositing carbon on the inside of the burner. Sometimes sufficient cleaning can be done with any sharp instrument, but more often a thorough boiling in a soda solution is necessary.

After an orifice has been reamed, the burner cock should be turned on and the issuing stream of gas lighted, in order to be sure that it will be central in the mixer.

When the complaint man finds an improper adjustment caused by an excess of air, which is evidenced by the flame being too hard, or by its flashing back into the mixer and burning at the orifice, he should reduce the air by closing the shutter. When an appliance is not provided with adjustable air shutters, the gas supply alone can be regulated in the attempt to obtain the proper flame. In many cases it is impossible to do this satisfactorily.

Many times a complaint is found to be due not to an improper adjustment, but merely to the consumer's ignorance of operation. The remedy for this is a full and clear explanation of the points about which there has been a misunderstanding.

Leaks

A leak at the joints of cast-iron burners, and pinholes, or small leaks, at casting defects, usually can be repaired with stove cement, but if elsewhere on the burner, or if too extensive to repair thus, the whole burner must be replaced. A leak at the barrel of a burner cock can be cured by greasing in or tightening, if the cock is not strained; otherwise, the cock must be replaced. A leak at the burner rail thread possibly may need only rejointing, but if the thread of either is stripped, a replacement is necessary. A cock that is hard to turn may or may not leak, but it may be remedied in accordance with the preceding rules. Leaks at other points of an appliance are rare, and should be treated as their nature demands. In practically every case a satisfactory temporary repair can be made with soap, which, of course, should be followed as soon as possible with the permanent remedy.

Miscellaneous Repair Work

The remedy for a complaint of improper adjustment or of leak may be the replacement of a part or parts of the appliance, or such replacement may be needed because of accidental damage, or of old age. This kind of repair may vary from replacing a very small item to a complete overhauling of the appliance. This last means usually that the appliance must be taken to the company's shop, as the work involved cannot be satisfactorily done on the consumer's premises. Whenever a complaint man is examining a range and estimating on the cost of repairs, he should make most thorough his examination of all concealed or interlocking parts, such as linings, burner box, and sheet-iron body, so as to prevent giving a price based on the renewal of a certain number of articles, only to find later, perhaps after removal to the shop, that others are required.

The complete overhauling of a domestic cooking appliance should involve a thorough cleaning and refinishing and the placing of all parts in first-class condition. The company's shop should be equipped with tanks or vats, of such size that the appliance can be completely immersed. This process is as follows: The appliance is stripped of all removable parts and a

complete examination made to learn what new material must be used. The skeleton is lifted by a chain hoist running on a monorail ceiling track over the cleaning tank, and then completely immersed for from one to five hours in a saturated solution of lye, heated to about 150 degrees by the use of steam coils or gas burners. The smaller parts, such as burners and linings, are placed in a wire basket and immersed at the same time. After the grease and rust has been thoroughly softened, the parts and skeleton are removed, placed on a drainboard, and cleaned with a wire brush. Then they are immersed in a tank containing hot water, and well rinsed, after which they are removed and allowed to dry. The various parts are refinished, if necessary, before being assembled. Opinions differ as to the value of different finishes, but in general, badly rusted or scarred nickel work should be renickeled; inside linings should be given one or two coats of dark noncorrosive compound; bodies, a coat of flat black; exposed castings, a coat of glossy black, and burners, one of stove blacking. The finished assembly, of course, is dependent on the receipt, or the presence in stock, of whatever new parts have been found to be required.

The complaint man taking orders for repairs, should have definite information in his possession about the probable length of time that will elapse before needed parts can be obtained, so that the consumer will be warned of possible delay. Parts for old types of appliances are quite often unobtainable. In some instances, certain parts of other appliances can be substituted; in others, the part, if of sheet metal, can be made; or, if of cast iron and all pieces are at hand, can be repaired by welding.

Each man should be encouraged to study the trouble characteristic of each appliance, and to report promptly anything that may result in improper service and in an unnecessarily great number of maintenance visits with a correspondingly increased cost. When working on an appliance with which he is unfamiliar, if he is not sure that the trouble complained of has been permanently remedied, or otherwise properly disposed of, he should refer the matter to his foreman for further investigation.

Enameled parts for domestic ranges have recently become popular, and while of attractive appearance, are a prolific source of complaint, due to the difficulty of perfect manufacture and to the ease with which they are damaged. The sale of these parts should be accompanied by the definite understanding that they cannot be guaranteed.

When a complaint is found to be due to a flue connection affecting the draught of a coal-burning appliance previously installed, it usually may be remedied by placing a damper, provided with a centre hole 1 inch in diameter, in the flue of the newer appliance.

When the company is active in the sale of appliances, and when it sells only those which have been properly tested in its laboratories and approved, there is little possibility of the existence of any appreciable number of really defective appliances.

If ordinary adjustments fail to remedy a complaint of poor cooking performance, it is likely that the design of the appliance is faulty; that is, that there is improper heat distribution or ventilation. In such cases there usually is no general remedy that can be prescribed, but the matter, if important enough, should be treated by an expert. The principles explained in Chapter LXII will serve as a guide in these cases.

Hotel Appliances

Adjustments and Repairs

In general, cooking appliances of the "hotel" class will include almost all those not included in the "domestic" class. It has been stated that visits to maintain domestic appliances usually are the result of a request by the consumer for attention. This is true also of the majority of installations in hotels and restaurants, and these visits are made by the regular complaint men. In some situations, the company has organized a division which not only attends to all the "complaint" work on appliances of this class, but also makes periodical visits to a large number of places, to make the gas service extraordinarily efficient. These visits vary in frequency from once a week to once every month, or perhaps two months. It has been found that they are very beneficial not only in keeping the appliances in proper operation, but also in pleasing the consumer, and making him a booster for cooking by gas.

The knowledge and the physical work involved in adjusting and otherwise repairing these appliances, does not differ from that described in the treatment of the domestic type, except, of course, that the work is usually more difficult and requires a longer time, job for job. The repair of leaks and miscellaneous troubles is cared for in the same way. It is an impossibility for such an appliance to be removed to the gas company's shop for cleaning and installing new parts, but, fortunately, this is seldom

necessary because of the more sturdy construction throughout, and the general tendency of the consumer to make repairs as soon as their advisability becomes evident, instead of waiting until the appliance reaches such a stage of unrepair that radical action is necessary.

SECTION III

WATER HEATERS

CHAPTER LXV

DESIGN

Introductory

The field of water heating by gas is one which cannot be covered in any great detail within the space allowable here. As in the case of cooking appliances, improvements are constantly being effected in the design and operation of gas-fired appliances for water heating, and new types are ever appearing. It is, therefore, not worth while to touch upon any but a few of the more commonly used types of the present time and explain in a general way their construction and operation.

Unlike cooking appliances, there are no general specifications covering water heaters. There are several reasons for this. In the first place, there is very little difference in the design and operation of cooking appliances, whether the appliances are intended for use in large or small, rich or poor homes. A number of the essential parts of cooking appliances, for whatever purpose designed, will be found interchangeable, or at least of the same design. In the case of water heaters, however, although their sole function is to heat water, a great difference is found in design and construction and in method of operation, according to the circumstances under which they are intended to be used. While it might be said, in the same way, that the function of cooking appliances is to cook food only, it can be readily seen that their use necessarily covers a very much broader field and many more classes of work than do water-heating appliances. The successful performance of a water heater is entirely independent of the person using it, but the success with which different kinds of cooking may be done depends, to a large

extent, upon the operator. In short, it might be said that cooking appliances exist in one general design for a variety of purposes, while water-heating appliances exist in a variety of designs for one general purpose. Accordingly, while it is not difficult to use a general specification for the construction of the cooking appliance, it is impossible to do so for the water heater.

The first water heaters were necessarily crude and inefficient. A variety of forms were tried in succession, each an improvement over the previous one, the final result being a form of what is now known as the circulating or tank heater. From this as a starting point, the various types of heaters in present day use have developed, and they may be grouped into five general classes:

Circulating or tank heaters,

Combination or storage heaters,

Automatic instantaneous heaters,

Multi-coil storage heaters,

Small instantaneous heaters generally known as the bathroom type.

A great disadvantage for a long time in the use of gas for water heating was the cost as compared with coal. In addition to this, it was impossible to maintain a supply of hot water unless the gas heater was kept burning constantly. This condition was naturally not looked upon with favor by those who were accustomed to a continuous supply of hot water stored in a boiler from the water back of a coal range. At the present time, however, it is possible with a storage heater to keep a boiler filled with hot water at all times, the gas supply being thermostatically controlled so that the water is held at the determined constant temperature. Another development of recent years is the automatic instantaneous heater, which operates only while a faucet is open, the main gas burners being extinguished when no water is being drawn. When it is considered that the price of gas has gradually decreased, whereas the price of coal has increased, and, in addition to this, a relatively high efficiency is obtained from modern gas water heaters, to say nothing of freedom from storage of coal and ashes, it can be seen that the field of gas water heating for domestic use is continually increasing.

The over-all dimensions of some standard types of water heaters are as follows:

Type	Diameter	Height
Tank—copper-coil	$6\frac{1}{2}''$	28″
Bathroom—contact	20 ″	30″
Automatic instantaneous (smallest)	23 ″	39″
" " (largest)	32 ″	59″

Tank Heaters

Jacket

A tank heater is one which delivers hot water into an independent boiler. It is also called a circulating heater, because of the circulation induced in the water by its heating. It may be divided into three principal parts: the jacket, the burner, and the "internal" or water-carrying parts. In the earlier types of water heaters, the jacket was a cylinder of sheet steel, riveted together along a vertical seam, and fitting at each end into a casting. In service, there was trouble from corrosion of the sheet metal, and to gain access to the internal, the inlet water connection had to be broken and the top casting removed before the jacket could come off. A great improvement was effected by the present-day use of a cast-iron jacket formed of two halves of a split sleeve, and the removal of whose retaining bolts is accomplished speedily. Another variation of the cast-iron jacket is with one-half serving as a door (Figure 221), which not only gives instant observation of the internal, but also avoids any danger incident to the absence of a pilot burner. The door lugs should be set between, and not over, the lugs on the fixed (back) casting, to prevent lifting the door off the hinges when pulling up on the handle to open.

The relation of the jacket to the internal it encloses must be such as to allow adequate passage for the products of combustion.

The obtainment of a durable jacket finish is one of the chief difficulties of construction. Black japan is the material generally used, but unless there is great care in its application, and the heater is of such design that the jacket temperature is kept down, as, for instance, by an asbestos lining, more or less complete burning or discoloration of the finish occurs after a short period of use.

Burner

The burner of a tank heater is similar to the top burner of a range, and is always made of cast iron. Its ports are always

drilled openings. The burner shapes are various, but the star is the most frequent. The mixer is usually tapped to receive the water-heater cock, the end of which is provided with a thread about 1 inch in length. The cap is held closely against the face of the mixer by a lock nut. For manufacturing reasons, the mixer tube is usually a separate casting from the burner head, the joint being machined gas tight and locked with a set bolt.

The water heater, like the gas range oven, affords an excellent opportunity for the rapid formation of an explosive gas and air mixture if the gas is turned on before the igniting flame is at hand. Therefore, as much thought has been given to, and precautions taken for, its proper lighting as for that of the oven. The designs without a swing door provided a pilot light outside the heater, which projected a long horizontal flame over the burner through a hole in the jacket. (See Figure 220.) With this construction, safety was assured by following the rule of never turning off the pilot light until observation through the pilot hole showed the main burner was lighted.

With a swing door, the pilot burner is omitted and the main burner lighted directly through the open door. This not only makes it certain that any failure to light will be seen, but also prevents the accumulation of any explosive mixture through such failure. The observation of the burner while lighted is possible through a cluster of small holes cored in the door casting, just above the burner level. The earlier design was one larger hole covered with mica, but the latter was continually being broken.

For the proper operation of any heater, there is needed sufficient combustion space; that is, clearance between the top of the burner and the bottom of the internal. Any impingement of the flames against the internal should not be sufficient to cause them to be chilled and to permit the escape of some unburned gas, with the accompanying danger from incomplete combustion.

The burners of tank heaters range in consumption from 35 to 50 cubic feet per hour.

Internal

The first internals were of iron, and of two general types: tubular and sectional. In the former, the burner, F, Figure 219, was beneath, and the products of combustion rose between a nest of vertical pairs of concentric pipes. The water entered at the bottom and went up through the centre in pipe A to the top

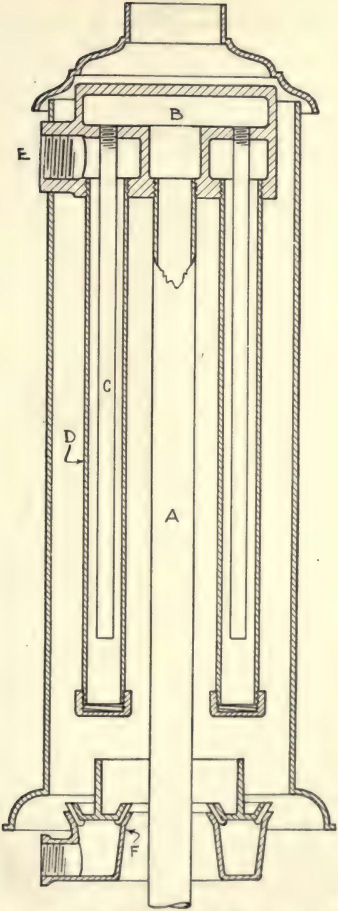


Figure 219.—Pipe Heater, page 730: A, Inlet Pipe; B, WaterHead; C, Inner Pipe; D, Outer Pipe; E, Outlet Pipe; F, Burner.

of the water head B. From there it descended through the inner pipes C, ascending in the annular spaces between C and the outer pipes D, whose bottom ends were closed by screw caps. At the top, the ascending water entered the annular space in the bottom of B, and from there emerged through the outlet pipe E. The prolonged contact obtained with the hot gases was made more efficient by the enveloping jacket, and the resulting economy of the heater was sufficient, with its low price, to make it widely used. However, because of its construction, it was rather easily clogged by sediment, so with waters carrying much solid matter, it did not prove as satisfactory as a heater of the second class, in which the water-carrying parts consisted of three superimposed cast-iron or (later) cast-brass sections, Figure 220.

Here the water went up the inlet pipe A, and circulated through the sections B. The products of combustion passed around the outside of the sections and through the vertical passages in them. The sections were so placed that corresponding passages in adjacent sections were offset and thus each section acted as a baffle, and longer contact with the products resulted. Where the sections were of brass, so were the connecting nipples.

Even with the sectional heaters, trouble from sediment and incrustation was frequent enough to furnish a lively incentive for a design which would combine long contact with the combustion products and a water path smooth and direct, and, therefore, capable of thorough flushing. This end has been achieved in the copper-coil heater, Figure 221. The coil is usually double, made of No. 20 gauge (Stubbs) seamless tubing, $\frac{3}{4}$-inch outside diameter, with a combined length of 18 to 25 feet. The inner coil contains the greater number of convolutions, and is from 3 to 4 inches in diameter, while the corresponding diameter of the outer coil is from 5 to 6 inches. The coils are brazed at both inlet and outlet ends to cast-brass fittings. These are locked at the jackets by lock nuts, and are tapped for the connecting pipes, ordinarily $\frac{3}{4}$-inch. Sometimes the ends of the coils form the female members of union joints, the male members being cast-brass manifolds tapped for the pipe connections.

If a single coil is used, it is of $\frac{7}{8}$- or 1-inch tubing. Triple coils are employed if high capacity is required. All coils are subjected by the makers to a hydrostatic pressure of several hundred pounds.

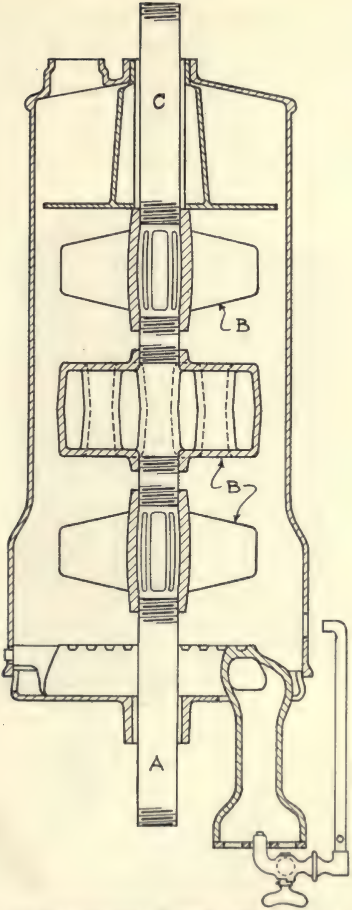


Figure 220.—Cast Sectional Heater, page 732: A, Inlet Pipe; B, Sections; C, Outlet Pipe.

Baffle plates, varying in design according to the ideas of the makers, but usually circular plates wired to the inner coil, are utilized to obstruct the products of combustion and thereby increase the absorption of heat. The efficiency of the heater depends appreciably upon the proper location of these plates with reference to the coils and to the jacket.

The average working efficiency of a tank heater is from about 50 to 55 per cent.

Figure 221.—Copper-Coil Heater, page 732.

Combination Heaters

The term "combination heater and storage system" is applied to any form of gas water heater in which the heating

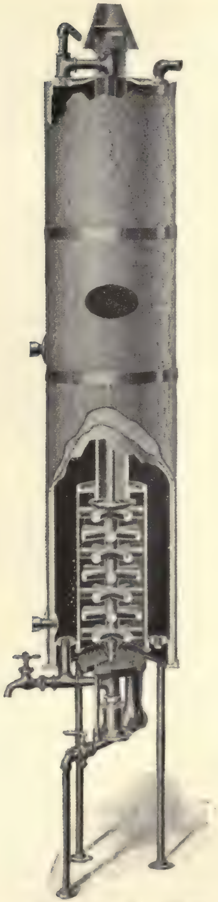


Figure 222.—Combination Heater, page 736.

unit is placed either within or beneath the body of an upright boiler specially constructed for the purpose. There is usually a central stack cut longitudinally through the boiler, the lower part of which is enlarged to receive the burner and an internal, if the latter is employed. The internal may be a copper coil, or one or more cast-brass or cast-iron sections. The upper part of the opening forms a flue for the products of combustion. See Figure 222.

The burners and burner cocks are of the same general design and construction as those on tank heaters, excepting that the burners are in one piece. They are also fitted with gauzes, as the combination heater is commonly employed for both automatic and nonautomatic service, the former requiring the gauze type of burner to guard against flash backs.

Those combination heaters in which a water-heating part is placed in the lower enlarged burner chamber, have the cold-water inlet pipe extended into the boiler about two-thirds its depth. The hot water outlet from the heater runs up through the flue space and connects into the top of the boiler at the same point where the hot water outlet from the boiler is taken off.

In one make of combination heater, no water-heating part in the combustion chamber is employed, the water being heated by passing up an annular space between the walls of the combustion chamber and another concentric shell of larger diameter, placed within the boiler proper and extending from almost the bottom of the boiler to a point about 6 inches from the top. The narrow flue passage extending from the top of the combustion chamber to the top of the heater is corrugated, to increase the heating surface, and a twisted flat bar, of the same length as the flue, serves to deflect the products against the corrugated surface and effect a high heat absorption. This construction leaves a comparatively thin layer of water in contact with the outside of the combustion chamber, and as this water is heated it rises and flows over the top of the concentric ring into the top of the boiler, and is displaced by cold water from the bottom.

The combination heater is used as an automatic heater by installing a thermostat (see page 741) in the bottom of the boiler, and thereby securing automatic temperature control. In this case, the outside of the boiler should be covered with lagging to reduce radiation. A flue is always provided to carry off the normal products of combustion and any unburned gases due to abnormal conditions.

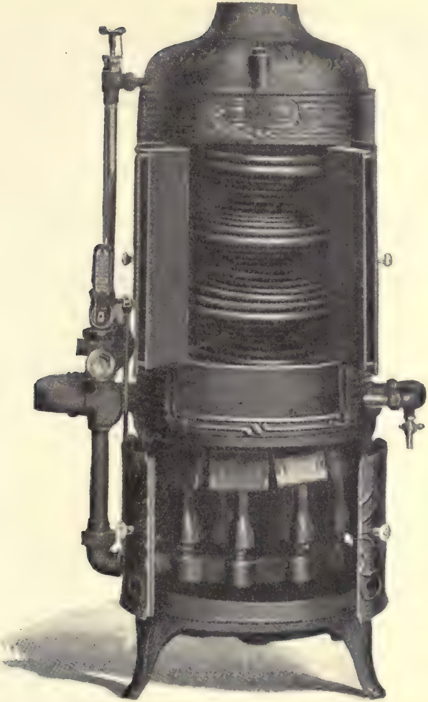


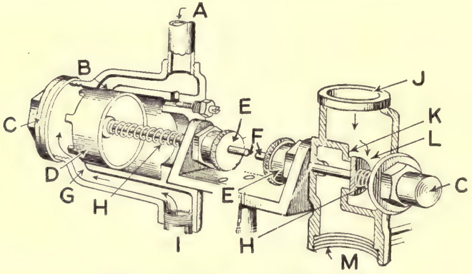
Figure 223.—Instantaneous Automatic Heater, page 739.

Instantaneous Automatic Heaters

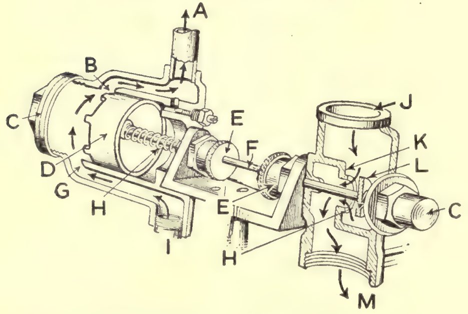
General

So far the heaters considered have been those using gas at a rather moderate rate and requiring some time to produce hot water. The fact that these early heaters were comparatively slow as hot water producers, and that dependence on them often involved aggravating waiting as compared with the

ability to obtain hot water at almost any time from a coal-heated system, helped, together with the high price of gas, to retard the introduction of water heating by gas. When, however, natural gas furnished a source of heat cheaper even than coal, human ingenuity soon provided an efficient, reliable means of using this



VALVES CLOSED I



VALVES OPEN II

Figure 224.—Automatic Water Valve, page 739: A, Water Outlet; B, Outlet Port; C, Cap; D, Plunger; E, Stuffing Box; F, Stem; G, Inlet Port; H. Compression Spring, I, Water Inlet; J, Gas Inlet; K, Seat; L, Disc; M, Gas Outlet.

gas to obtain hot water as fast as it could be delivered to the open faucets. Heaters of this class are very properly called "instantaneous automatic," Figure 223, because, as will be apparent from the description that follows, the opening of a hot water faucet operates a water valve, and this in turn lights the main gas burner, which is of such size that the water issues from the heater at the required temperature. In brief, no hot water is being made unless a faucet is open, and then the production of the water required is practically instantaneous. To do this requires a high rate of gas supply, and unless proper provision is made for this, the heater will not furnish sufficient hot water, and in addition, the gas pressure at any other appliances supplied from the same source will fluctuate sufficiently to interfere with their proper performance.

Automatic Water Valve

The automatic water valve is probably the most vital part of this appliance. Before describing its construction, a simple explanation of the principles governing its action will be given.

Figure 224 shows a type of water valve, with the accompanying gas valve, in the closed, I, and open, II, positions. The various parts of the valves can be clearly understood by an inspection of the figure. The supply line to the heater is connected to the water inlet on the bottom of the valve, and the line running to the hot-water faucets is connected to the water outlet by way of the coils. The passage of water and gas through their respective valves is as indicated by the arrows.

Assume, now, that the valve and pipe lines running to the hot faucets are filled with water under street pressure, the faucets being closed, the street water pressure, acting through the inlet port against the face of the plunger, will be taken as 25 pounds per square inch, the plunger area as 7.06 square inches, and the tension of the compression spring, 2 pounds. With all the various hot faucets closed, the plunger is in the position shown in the upper sketch. A small hole, not shown in the sketch, drilled through the plunger, serves to equalize the water pressure on both sides, this pressure now being 25 pounds per square inch. Suppose that the highest faucet in the house, located 34 feet above the heater, be opened, the pressure on the house side of the plunger becomes that exerted by a column of water 34 feet high, or 15 pounds per square inch, plus the 2 pounds exerted by the spring. This gives, roughly, 107 pounds, while the pressure

on the street side is, roughly, 175 pounds. The plunger accordingly will move forward to assume the position shown in II. After moving a short distance, the plunger uncovers the outlet port and so permits water to flow through the valve directly to the faucets. As it moves forward, its stem engages the stem of the main gas valve placed in line with it, as shown, and unseats it against the compression spring, thus permitting gas to pass.

When the hot-water faucet is closed, the 25 pounds pressure from the street side builds up through the equalizing hole until the water pressure is again the same on both sides of the plunger. The pressure exerted by the spring is then sufficient to move the plunger back to its original position, as shown in I, the main gas valve being also closed by the compression spring. Each time a hot-water faucet is opened, the cycle just described is repeated.

There are two types of plungers in general use, one being a packed plunger, which is machined to a comparatively loose fit in the cylinder, and is then, by cotton or other packing, made tight enough to prevent leakage around it. The second type is a metal contact plunger, which is turned to a working fit with the cylinder walls.

The usual location of water and gas valves is with their stems in line, as illustrated, but in some heaters they are placed at right angles to one another. In any case, they are rigidly held in their relative positions by being bolted to a cast-iron or brass yoke, so that the stem cannot be thrown out of line by the strains due to pipe connections or other accidental causes. When the heater is not in action, there is a small clearance between the abutting ends of the water and gas valve stems, to allow the water valve to open slightly in advance of the gas valve.

The water ports in the cylinder may be simple rectangular openings or slots. In some designs the port is in the plunger itself, and is opened by the gradual recession of the plunger from a tapered plug. The cylinder head is threaded on and made tight by means of a gasket. To prevent leakage and yet avoid undue friction, there is a stuffing box with glands where the stem passes out of the cylinders.

Plungers must be large enough to move the mechanism under normal water pressure. For locations where the pressure is very low, larger coils, in conjunction with special valves with larger plungers, are used.

Gas Valves

The disc of the main gas valve (Figure 224) generally carries a leather washer, which makes a gas-tight joint with the brass seat. The spring in this valve is usually of phosphor bronze, but sometimes of steel with a coating of japan as a protection against corrosion.

In some heaters there are two gas valves, one of which, called the main gas valve, is acted on by the automatic water valve, and the other, called the thermostatic gas valve, is controlled by the thermostat. In other types a single gas valve is acted upon by both water valve and thermostat.

Thermostats

The thermostat is a contrivance for automatically shutting off the gas when the water reaches a predetermined temperature. It generally consists of a copper tube, twelve or more inches in length, one end of which is closed by a solid head and the other end permanently fastened to a frame in which a system of multiplying levers swing. A porcelain or carbon rod is fitted loosely in the tube. One end of the rod is either shod with a steel button or abuts on a short brass plug which has a steel pivot on its end. This pivot presses on what (in the simplest forms) is the short arm of a simple lever, the long arm of which acts on the thermostatic gas valve. The fulcrum of the lever can be adjusted by means of a screw having a lock nut, and in this manner the valve can be set to close off at any desired temperature. In the more complicated types, a system of compound levers is used, but the principle is the same.

The copper tube is inserted in an extension of the outlet end of the coil. By reason of the difference in expansion between the copper tube and the porcelain or carbon rod placed within it, the thermostatic levers are made to operate. A spring, of course, is provided to regulate the expansion forces.

Burners

The burners, Figures 225 and 226, consist essentially of four parts: the burner cap, A, the mixer tube, B, the gauze, C, and the orifice spud, D. The spud is drilled with a so-called "fixed orifice" and is screwed directly into the burner manifold, E. In the usual construction the spud consists of two parts screwed together, the upper part carrying the orifice known as the spud cap. The mixer tube slips loosely into place over this spud.

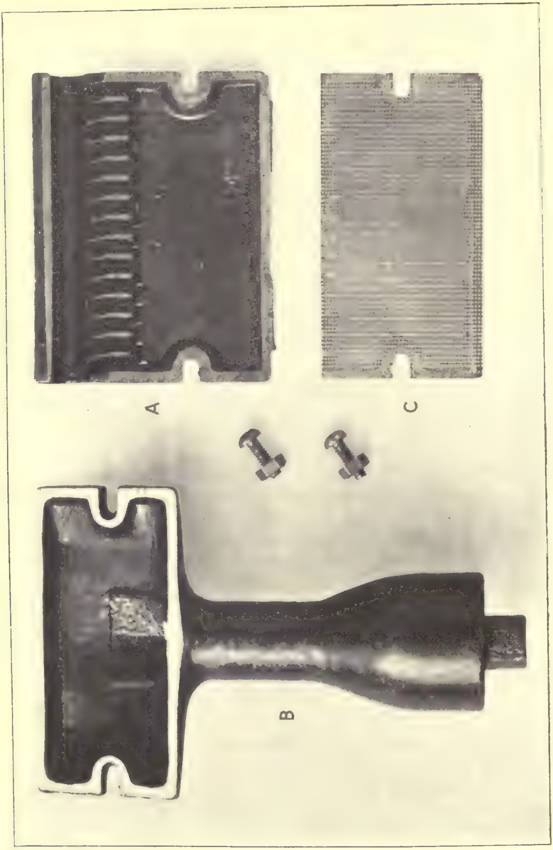


Figure 225.—Burner of an Instantaneous Automatic Heater, page 741: A, Burner Cap; B, Mixer Tube; C, Gauze.

The mixer tube is bell-shaped at its bottom and tapers up to the burner head, which is generally a rectangular box-like casting, making an angle with the vertical mixing tube. The primary air openings are fixed openings located in the base of the mixer. The gauze is placed across the burner head and is clamped down by the burner cap, which is bolted to the tube. The caps are so designed that any condensation falling on them is shed and thereby prevented from entering the burner ports.

The gas consumption ranges from 90 to 480 cubic feet per hour, according to the size of the heater, and, in general, each cubic foot will raise 1 gallon of water 63 degrees in 1 minute.

The pilot burner head is made of soapstone, lava or some other refractory material, and is threaded on to a $\frac{1}{8}$-inch pilot line by a socket. It is cylindrical in shape, with a hemispherical cap, the ports being placed just under the cap.

There is a main cock on the gas supply line, which is usually of the quarter-turn, lever-handle type.

The pilot line is taken from the gas supply line at a point just in front of the main cock, and is equipped with its own cock and a regulating screw to fix the length of the flames.

Coils

The coils are made of seamless copper tubing, and vary from $\frac{1}{2}$-inch to 1-inch in diameter. They are wound in a series of cone-shaped spirals, the apexes and bases of adjacent cones being opposed. The length of the coil varies for each size of heaters. The bottom part is usually made detachable from the rest of the coil, to facilitate repairs. The coils are supported by hooks or racks, which are attached to the inside of the jacket.

Jacket

The jacket is of cast iron, and above the burners has cast-iron linings providing for air space insulation. The upper jacket always has a front double door, and in some cases a double door is also provided at the back. The lower jacket always has a front double door to give access to the burners. All doors used are held shut by spring tension. The doors are fitted with enameled or brass direction plates explaining the method to follow in lighting the heater.

Regulating Water Valve

There is a regulating water valve, which is usually located at the top of the heater where the cold water enters the coil. This valve is made necessary by the varying pressures encountered,

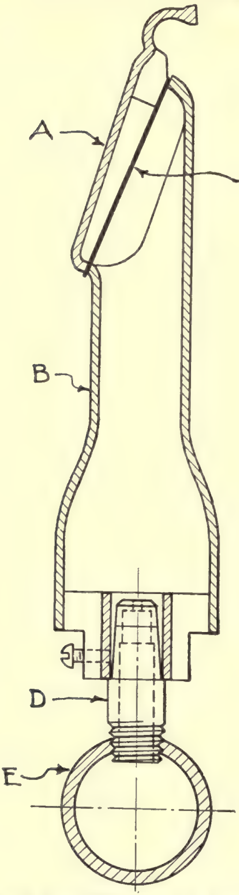


Figure 226. — Sectional View of Burner of Instantaneous Automatic Heater, page 741: A, Burner Cap; B, Mixer Tube; C, Gauze; D, Orifice Spud; E, Burner Ring.

and throttles down the water supply to the maximum capacity of the heater. It is covered by a brass screw cap to prevent tampering.

Multi-Coil Heaters

The multi-coil heater is adapted for use with large storage heaters, and its equipment includes a thermostat for automatically controlling the gas to the burners. In general design it resembles the automatic water heater. It comprises a number of short copper coils, connected in parallel to two manifolds; a battery of bunsen burners, mounted on a cast-iron manifold; a pilot; a cast-iron jacket, and a condensation cup. In some makes of heaters, the manifolds run vertically, one on each side of the heater, while in other makes the manifolds run horizontally at the top and bottom of the heater. In the vertical manifold heater, the coils are graduated in diameter, the largest coil being at the bottom and the smallest at the top. In the horizontal manifold heaters, the coils are of the same diameter. As in the instantaneous automatic heaters, the size of the coil varies with the size of the heater.

To give a free circulation of the water and reduce friction to a minimum, the area of either manifold is made equal to the combined cross sectional area of the coils.

The hand-operated valves on a multi-coil heater consist of a main valve controlling the gas to the burners and a pilot valve controlling the gas to the pilot burner.

The thermostat, which is the only automatic mechanism used on this heater, is one of two types, i. e., the "graduating" or slow-acting type, and the "moment" or snap-acting type. The graduating valve is similar to that used on the instantaneous automatic heater. A type of moment valve is shown in Figure 227. The gas valve is shown in its open position.

As the water in the boiler becomes heated, the copper expansion tube A, projecting into the center of the boiler, expands, allowing the porcelain rod B, the brass thrust block D, and the steel thrust rod C, to move to the right. This permits the multiplying levers E and F, fulcrumed at "e" and "f" respectively, to move to the right, the entire movement being effected by the pull of the tension spring G. The end of the lever H operates over the spindle of the gas valve J between the stops as shown. The upper arm bears against the trip spring I. As H moves upward it compresses the spring I, and

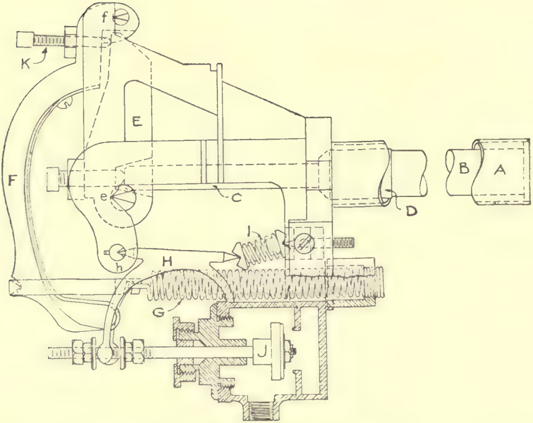


Figure 227.—Moment Valve, page 745.

at the same time moves it upwards, nearer to a horizontal position. The spring I in compressing, retards H until it has just passed beyond the horizontal position (its dead center) when suddenly, on passing the dead center, it releases, accelerating the movement of H and seating the valve disc with a "snap" action.

When hot water is drawn off, each part of the above action takes place in the opposite direction. It will be noted that the result of this action is that the gas valve is either full open or tightly closed, and no graduation of the gas supply is permitted.

For the storage of the heated water, tanks of suitable size are used. Stock sizes of these tanks run up to 500 gallons, but larger tanks can be procured. These tanks are usually lagged to reduce losses by radiation to a minimum.

Bathroom Heaters

The bathroom type of water heater is a small heater of one or two gallons per minute capacity, designed for installation at the point at which the hot water is used. It is generally mounted upon a shelf fastened to the wall, in the room containing the fixtures to be supplied with hot water. The shelf, in most cases, is constructed of pressed steel, conforming to the lines of the

base of the heater shell, and is either nickel-plated or porcelain enameled. To carry off condensation, a threaded outlet is provided in the shelf to which a permanent drain connection may be made.

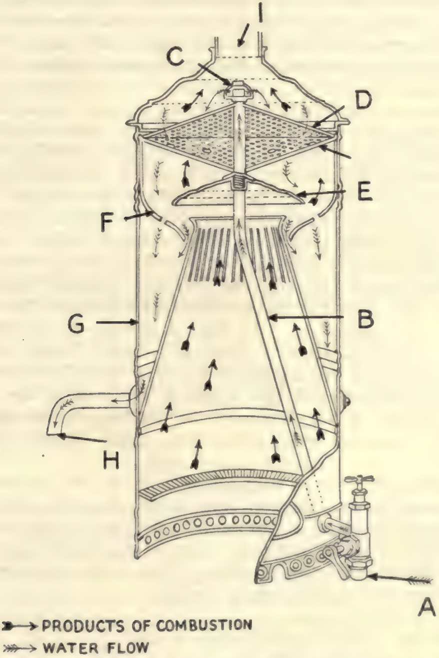


Figure 228—Bathroom Heater - Contact Type, page 748: A, Cold Water Inlet; B, Standpipe; C, Spray Head; D, Contact Screen; E, Baffle Cone; F, Collector; G, Shell; H, Hot Water Outlet; I, Vent.

There are two general types of bathroom heaters, namely, the contact and the pressure, the former also being known as

the geyser type. In the contact type, Figure 228, the water is sprayed in a thin film over a perforated contact screen through which the products of combustion pass. It drops from the screen to a baffle plate and then through a funnel-shaped collector to the outside of a copper cone, within which is placed a yellow or illuminating flame burner. The base of this cone and the heater shell form a water-tight joint, and the water, collecting at the junction of these two parts, is led off through a delivery tube.

The burner of this heater consists of a number of parallel brass pipes, drilled with numerous small orifices from which the gas burns in short jets. The heater is equipped with a main gas valve controlling the burner; a pilot valve, used in lighting the burner; a water valve for turning on the water, and a water-regulating screw for regulating the flow of water in accordance with the prevailing pressure in the house pipes. The pilot, main gas and water valves are so interlocked that the operator is compelled, when lighting the burners, to first turn on the pilot valve and then the water valve, after which the main gas valve may be turned on. In this manner, the danger of an explosion of the gas, due to lighting a large volume of it in an enclosed space, and the danger of burning out the internal parts of the heater because of the absence of water, are avoided. The pilot burner is not designed for continuous service, but is extinguished immediately after the main burner has been lighted.

In the pressure type of bathroom heaters, the heating surface generally consists of copper tubing, which is coiled spirally as in the automatic heaters or wound in any other form considered desirable by the manufacturer. The burners are of either the bunsen or illuminating flame type. The valves are the same as for the contact or geyser type of heater.

Conditions of Use

Circumstances of Consumer

The type of heater recommended must obviously be adapted to the circumstances of the consumer as regards cost, although the kind of service required should not be lost sight of, as the satisfaction of the consumer will depend principally on this factor.

The company's representative would not attempt to sell in the tenement district the same automatic service that he would offer in the wealthy residential section, although the needs of

the two parties as to the amount of hot water required might be identical. The tenement dweller could not afford the automatic type, and must select the most suitable heater within his means. In the wealthy districts, it is more often a question of selling service to the consumer, with price as a secondary issue. Between these two extremes, we have the middle or average residential class. In this case, both factors, namely, cost and service, enter more closely into the selection, but in this field we have more available types embodying both these factors.

Space Available

The heater used will be determined often by the space available. A kitchen location would call for either a circulating heater or a combination boiler and heater, both without thermostatic control, since the necessity of lighting a heater each time hot water is desired involves a minimum of inconvenience with the heater in the kitchen, while in such a location thermostatic control is unwise, as the continuously burning pilot is liable to extinguishment either from drafts or from tampering by children or servants.

For a cellar location any type may be used, but the most convenient forms are the automatic instantaneous, or the automatic storage, for the pilot ignition makes these heaters self-acting, and in the cellar the pilot is not apt to be interfered with.

Character of Work

Light Demand

Where a small quantity of hot water is needed intermittently, as for a small family, a circulating heater connected to an independent (coal range) boiler, should be used. This condition is usually found in the smaller dwellings where the circulating heater is connected in parallel with the water back and range boiler. The heater would thus supplement the water back, or it could be used to heat the boiler independently. If there is no existing boiler, a nonautomatic combination heater and boiler might be used. This could be supplemented by connection to the water back of a coal range, a kitchen heater, or a coal laundry stove. In this latter case, the gas heater would probably not be needed when the laundry stove was in use. The capacity of the boilers generally used in these cases would probably not exceed 24 to 30 gallons. For a situation such as small barber shops, requiring a very small supply of hot water at any one time, a 5-

or 10-gallon barber's boiler should be used. This is a combination boiler and heater, either with or without thermostatic control.

In a location unprovided with hot-water piping, a heater is needed which can be placed at the point of use of the hot water. For this condition, if the demand does not exceed one to one and one-half gallons per minute, the bathroom type is suitable, Figure 228.

Moderate Demand

Where a moderate quantity of hot water is needed at fairly regular intervals, as in the larger dwellings and in small restaurants, the requirements can be met by the smaller sizes of automatic instantaneous heaters (not larger than 4 gallons per minute) or by the medium-sized storage systems, both usually in conjunction with an existing supply of hot water furnished by some coal-burning appliance. In the latter case, the heater is connected by what is known as the reheat system, which permits the heater to be used alone, or to supplement the existing hot-water supply, or to be idle if the existing supply suffices. It is obvious that this method of connection is more economical than the direct system, and unless it is desired that the gas heater be prepared to supply all the hot water required, there is a saving in first cost due to the use of a smaller heater.

Heavy Demand

In the field of heavy demand belong large restaurants, hotels, clubs, bathhouses, etc., where large quantities of hot water are used either continuously or at short intervals. These require large automatic heaters, either instantaneous or in connection with storage systems. When the demand is heavy and uncertain, the installation should be large enough to care for the peak load Any existing supply of hot water should be utilized by a reheating system.

CHAPTER LXVI

CONNECTION PRACTICE

Preinspection for

Location of Appliance

Consumer's Wishes

The routine described in Chapter LXIII should be followed in conferring with the consumer, and, wherever possible, his wishes about location should be complied with. Because of the relatively small size of circulating heaters, there is little chance of objection to any location selected by the workman. This also applies to other types of heaters, since, while they are larger, the installation is almost always in the basement or cellar, and, therefore, the consumer is not greatly concerned in the choice of location. If an objection is raised, an explanation of the reasons for the location chosen will usually result in its acceptance without further question. If the heater is a large one, or the connections are complicated, the location should be marked on the floor, the connecting pipes should be properly tagged and the flue outlet designated.

Fire and Other Hazards

The only fire hazard usually created by a circulating heater is that to the adjacent wall. When this is of an inflammable character, the heater should not be placed closer than six inches, unless the wall is protected as described on page 704. No circulating heater, or combination boiler and heater unprovided with a flue, should be placed so that the flue outlet is vertically nearer than 18 inches to an inflammable construction unless a proper protection is provided. As ordinarily located, no fire hazard is created by the installation of a storage or automatic instantaneous water heater. Under special conditions, protection of the sort just described should be given.

Because heating water by gas requires no attention during the process, thus differing from gas cooking, and because of the

small size of the circulating heater, it is possible to find room for such an one in a closet or in a semiclosed place, like the top landing of a cellar stairs, which, with room at a premium, is often used for the boiler location, and in that case efficiency of operation would call for the heater there also. There are, however, two important reasons, both of which may be urged against the closet location and one, or both, against the cellar stairs. Every gas burner needs an ample supply of air and a free vent for the combustion products. Without the first, there may be incomplete combustion with the formation of carbon monoxide, a direct poison. Without the second, the proportion of carbon dioxide will become unduly high in the atmosphere surrounding the heater. The second objection makes it inadvisable to connect a heater in a bathroom, as these rooms are usually of such small size that the volume of combustion products bears too large a proportion to the total room contents.

The cellar stairs location is also objectionable, as the heater is out of sight and, therefore, the consumer may easily forget to turn it off at the proper time, thus not only wasting gas and laying the foundation of a high bill, but possibly generating steam, which, in rare cases, might cause damage especially on a metered water supply, this not allowing any relief of the excess pressure by return to the street main.

Appearance and Ease of Connection

It is desirable that the installation be unobjectionable and unobtrusive in appearance. This is especially true in a finished room or in one of average size. With a circulating heater, this requirement, and also that of economical operation, is obtained by a location close to the boiler. Appearance also calls for the ornamental face to the front and for a position well off the floor, though in this matter of height the circulation requirements will be paramount. The appearance of the gas and flue (if any) connections must also be considered. Here efficiency has little or no concern, and if there is any difficulty, it will be usually with the flue.

Heaters larger than the circulating type are generally in the cellar, and, therefore, not ordinarily in a finished room. When they are, the heater itself usually makes a presentable appearance, but again the flue connection may be the difficult problem from the standpoint of appearance.

Operating Results

For the most economical operation, a circulating water heater should be not only close enough to the boiler, but also low enough to give a fast circulation to the issuing hot water. Such a location is usually obtainable, though in some cases its advantages may be overridden by the requirements of a flue connection.

Combination and storage heaters in kitchens should be placed near any coal range, and in cellars near the house heater.

Instantaneous heaters, subject to those previous considerations which call for a cellar location, should be placed to deliver their hot water to the desired points through the shortest distance. Also any preheater should be near by. A cellar location usually affords all of these advantages, as well as satisfactory flue connections.

Condition of Appliance

The routine described under this heading for a cooking appliance, on page 705, is followed. If, as is usually the case, there is work to be done on the boiler or water pipes, they should be examined. If found in poor condition, the consumer should be made to understand that the company will not be responsible for any extensive damage that may occur to them.

Service

Except for an instantaneous heater, no enlargement of the existing service will, as a rule, be required. In any case, if it is not certain that the size need be increased, a trial should be made of the completed installation before incurring the considerable expense usually incident to a service change.

Meter Connections

The limits of meter capacity, as shown on page 456, are so well fixed, and the cost of any necessary change is relatively so small that the indicated size should be set without any preliminary trial. A prepayment meter should never supply an automatic heater.

Appliance Line

The use of an existing line, or the size of a new line, should be governed by the same considerations described on page 706.

Water Pressure

For each instantaneous heater, there is a minimum water pressure required for proper valve operation. Before taking any steps toward installation, the adequacy of the available pressure should be ascertained. The measurement should be taken at the highest hot-water faucet and at a time when the street pressure is lowest. Any leaks in the house system should be repaired before the test is made.

Material and Tools

The conditions attending water heater work are so varied that the advantages of doing it under a preinspection system are even greater than obtain for cooking appliances, and the decisions and calculations previously mentioned are considered as being made by a preinspector. His relation to the necessary material is as described on page 708.

Connection

Shutting Off and Turning On Gas and Water

The remarks on page 708 apply here, with the additional statement that water supply is also involved. On the other hand, the gas shut-off is apt to be of shorter duration than when connecting a cooking appliance, as in the case of a circulating water heater the gas supply is generally easily and quickly obtained from the existing line to the cooking appliance.

Running Piping

Circulating Heater

The preinspector has already called the attention of the consumer to any visible defects in boiler or water piping, and, therefore, the fitter presumably should not have any duty in this line unless new conditions develop as he proceeds which clearly have not been due to his work.

As the satisfactory operation of the heater demands clean water, it is first necessary to remove any dirt existing either in the water back, the boiler or the connections, that might be forced into circulation by the new conditions. If, with water shut off, dirt is found to exist on drawing off water from the low point in the connections, the boiler should be entirely emptied and then partly refilled, repeating this process until all the dirt is removed.

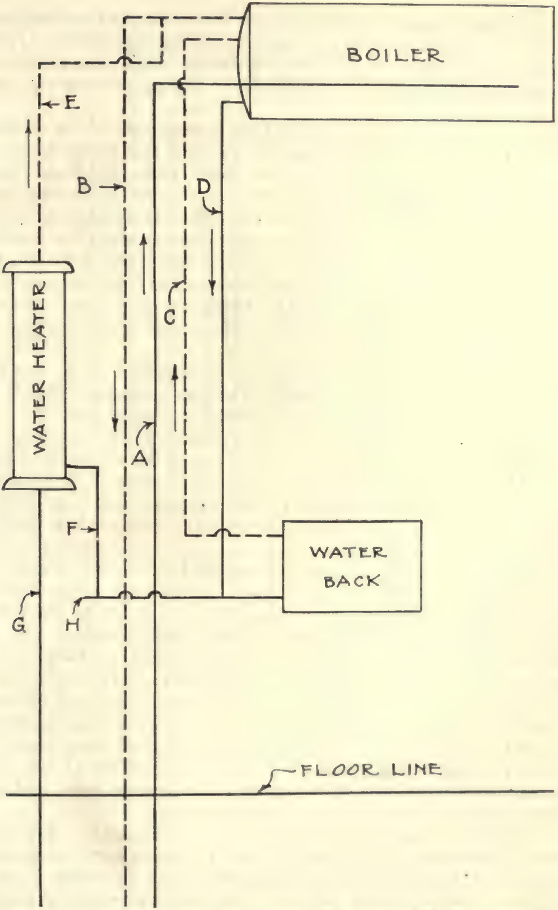


Figure 229.—Connection to Ordinary Horizontal Boiler, page 756.

The illustrations that follow show the method of making water connections to various types under varying conditions. Except as otherwise stated, solid lines represent piping conveying cold or preheated water, and dashed lines piping conveying heated water.

Figure 229 shows the method of connection to an ordinary horizontal boiler, which is heated also by the water back of a coal range. A is the cold-water line from the house water supply to the boiler; B, the hot water from the boiler to the house fixtures, and C and D, the connections between the water back and the boiler. The pipes that are installed by the fitter when connecting the heater, are E, the hot-water pipe from the heater to the boiler; F, the cold-water pipe from the boiler (or water back) to the heater, and G, the gas supply line. A $\frac{1}{2}$-inch clean-out plug is placed at H, for the purpose of cleaning out, as mentioned on page 772.

Figure 230 shows the method of connection to an ordinary vertical boiler with water back. The explanation of the various letters is similar to that already given for Figure 229.

Figure 231 shows the method of connection to what is commonly termed a log boiler. This is found usually with the old-style, bricked-in coal range, and presents certain difficulties of installation because the pipes to which connection must be made are of lead, and because the boiler is relatively so low that it is difficult to obtain good circulation. A is the cold-water line from the house supply to the boiler, and B, the hot-water from the boiler to the house fixtures. The water pipes that are installed by the fitter are C, D and E. In order to prevent the water that is drawn through B from coming directly through the heater instead of from the boiler, and to facilitate the hot water storage in the boiler, it is necessary to install a 24-inch length of 2-inch pipe in line E. This results in enough difference in weight between the columns D and E to cause circulation toward the boiler until a faucet is opened, and then its effect is to reduce the friction loss in E as compared to D, and so to cause the movement of the water in the proper way. H is the clean-out plug, and G the gas line installed.

If it has been found necessary to completely empty the boiler, the water connections should be made while the boiler is empty. If, however, no dirt appears, the connection should be made in the following manner. All the faucets on the system from which water is shut off, should be opened and water drawn

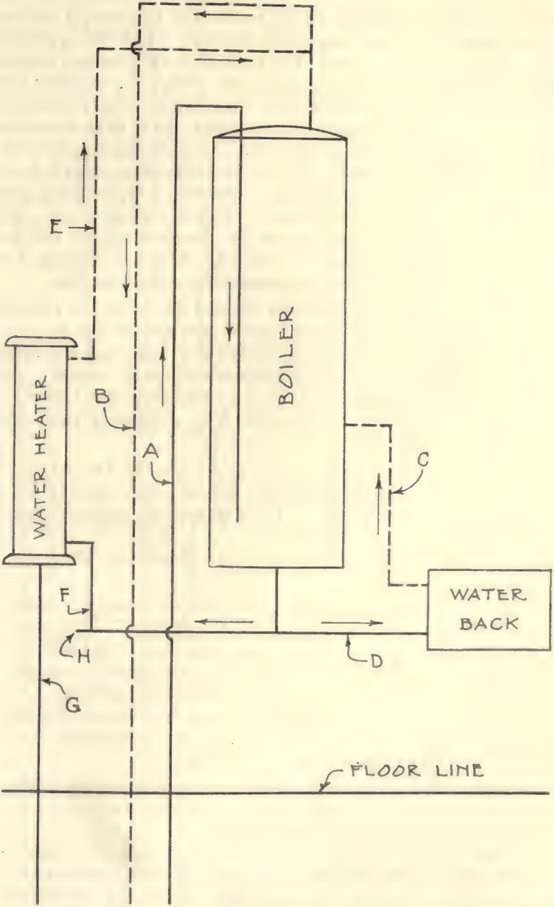


Figure 230.—Connection to Ordinary Vertical Boiler, page 756.

from the lowest available point below the bottom of the boiler until the latter is about one-third empty. The faucets should now be tightly closed, and if no air leakage exists, the cold-water pipes to the heater can be run with a very small loss of water from the open boiler outlet from which the connection is being made. If the system is not tight, or if it is desirable to spill no water, the boiler must be emptied completely before the connection work is started. When the cold connection is finished and the heater placed upon it, a vertical nipple, long enough to reach above the level of the water, if any, in the boiler, should be inserted in the top outlet of the heater. Now the boiler connections can be broken at the top, without further loss of water, and then the hot-water connection can be made.

At this point an investigation should be made to determine whether a cold-water carrying tube is already in the boiler. If not, one should be inserted, as it is very essential for efficient operation. This tube should be preferably of copper, one or two $\frac{1}{16}$-inch holes being drilled in it at the entrance end.

In making the water connections, the following rules should be followed:

> The size of the connecting pipes should be that of the outlets provided in the heater, but should be never less than $\frac{3}{4}$-inch. Galvanized or copper pipe and fittings should be used.
>
> Cocks or valves should not be placed on the connections.
>
> If the water to the house is metered, a safety valve should be placed on the top of the boiler. This is to provide against excessive pressure in the system created by steam generated in case the heater is allowed to burn for a considerable length of time.
>
> A union should be installed on each of the cold and hot connections. Good quality fibre washers are recommended for use in these unions.
>
> A $\frac{1}{2}$-inch plugged outlet, provided, if desirable, with a draw-off cock, should be placed on the lowest accessible point of the circulating system.
>
> As tight joints are a requisite, extraordinary efforts should be made to pull each thread very tight as the connection work is proceeding. Jointing material should be used sparingly.

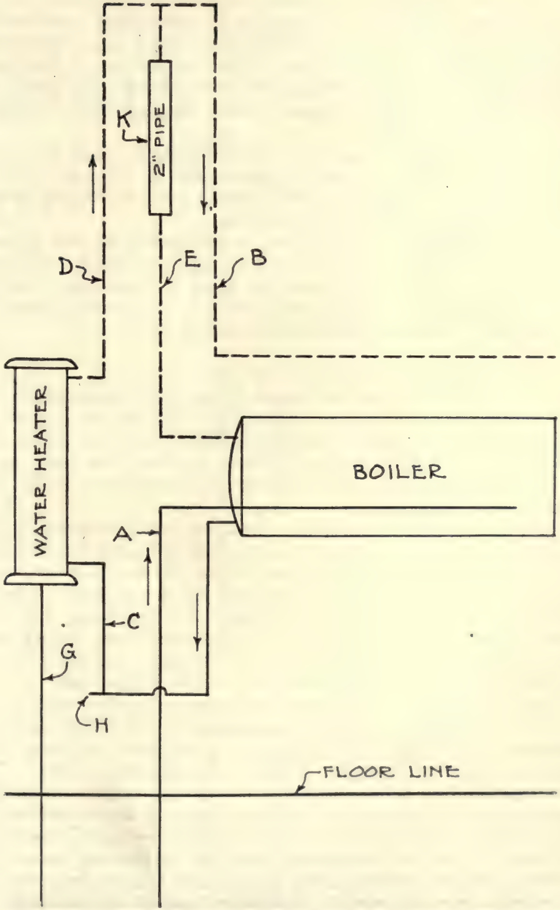


Figure 231.—Connection to Log Boiler, page 756.

The water connections having been completed, the water should be turned into the boiler and the pipe joints carefully examined to see if leaks develop. Close attention to this may show the leaks as soon as the water level reaches the defective joint, and will save time in cases where emptying the boiler is necessary to make repair.

The water work having been completed, the gas and flue connections should be made as explained in Chapter LXIII. A flue should be installed on every water heater burning at the rate of more than 35 cubic feet per hour.

The heater should now be lighted, a temporary or final adjustment given, and a brief test of the installation made. Fifteen minutes will usually be sufficient to bring to light any defects, such as by-passing, obstructions or leaks. If any such fault is noticed, steps to remedy it should be taken at once.

Combination Heater

After the preinspection, the work of the fitter preliminary to the connection of a combination boiler and water heater is almost exactly the same as just explained for circulating heaters. As the combination heater sometimes replaces the coal range and boiler, special care should be exercised in the removal and disposition of the latter.

Figure 232 shows the method of making water connections to a combination boiler by the "direct system," so-called because the water enters the heater direct from the cold-water house service. A is the cold-water line from the house water supply, and B, the hot water from the boiler to the house fixtures. C and D are, respectively, the cold and hot water connections that are made by the fitter. E is a gate valve. A clean-out is provided at the bottom of the boiler. G is the gas line.

Figure 233 shows the method of making connections to a combination boiler by the "reheat system," so called because the water entering the heater has previously received some heat from an auxiliary system, usually the kitchen boiler. The advantage of the reheat system lies in the reduction of the amount of gas necessary to raise the volume of water within the boiler to the temperature that will close the thermally-controlled gas valve. The reheat system, therefore, is the one most frequently used for dwelling houses. A is the supply line carrying the previously heated water to the boiler, and B, the line from the boiler to the house fixtures. It can be seen that before the

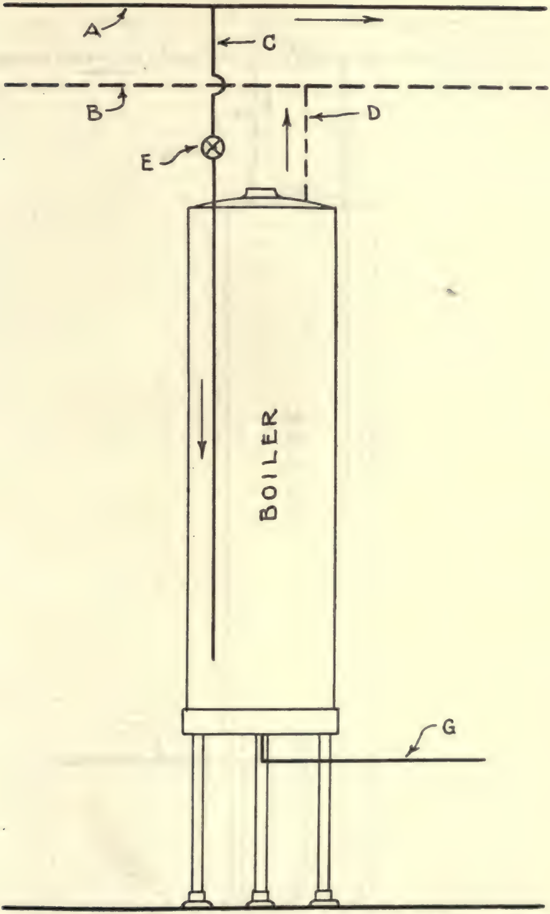


Figure 232.—Combination Boiler Connection—Direct System, page 760.

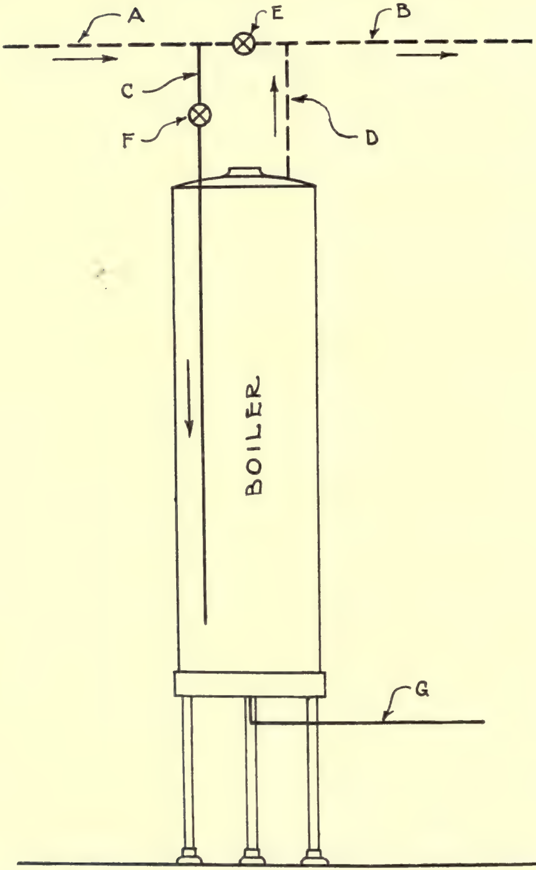


Figure 233.—Combination Boiler Connection—Reheat System, page 760.

heater was installed, A and B formed a continuous line from the previous sole source of water heating to the fixtures. The lines C and D conduct the water to and from the boiler respectively. It is seen that when valve E is open and valve F is closed, water will flow from the initial source of heat direct to the fixtures without passing through the boiler, and that when valve E is closed and F open, the water to the fixtures will be drawn from the boiler. It is necessary that these two valves be neither both closed, or both open, at the same time. The consumer should thoroughly understand their functions.

The gas and flue connections should be made and all other work done as described in Chapter LXIII.

The small capacity boilers of the type used most frequently in barber shops, in which the water is heated by application of the gas flame either directly to the bottom of the boiler or to a system of castings or coils contained in, or under, the boiler, similarly to boilers of larger type, are located usually on the floor, no flue connection being required.

Figure 234 shows the method of making water connections to such a boiler type. A and B are the cold and hot water con-

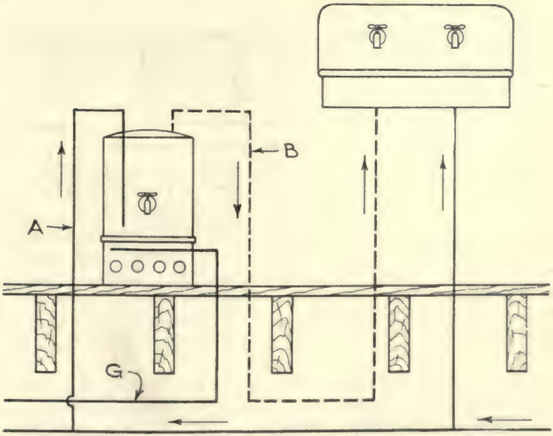


Figure 234.—Barber's Boiler Connection, page 763.

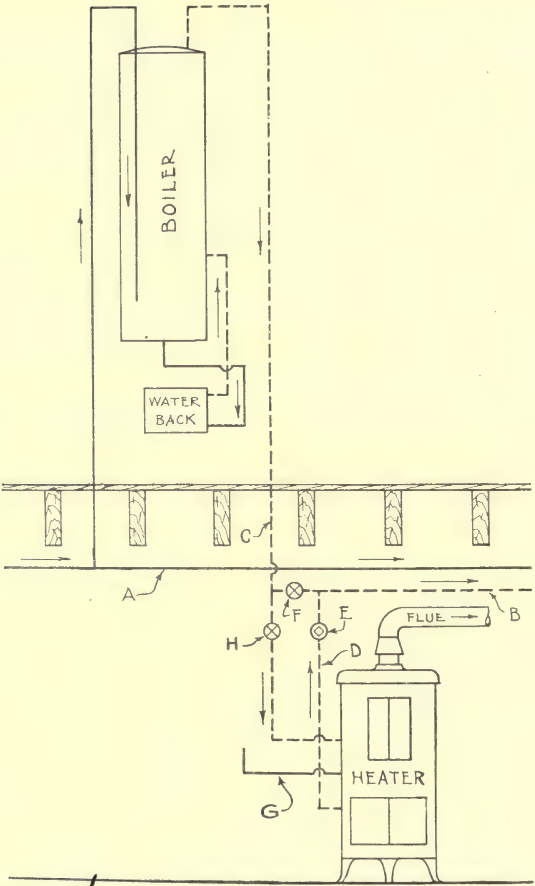


Figure 236—Instantaneous Automatic Heater Connection—Reheat[redacted] System, page 765.

nections, and G, the gas line. This figure shows the water being received from the cold-water supply to the house. This may be varied if desirable, and the reheat system used by making the connections in the way shown in Figure 233.

Instantaneous Heater

Bearing in mind the details of construction of the instantaneous type of water heaters, the methods of connection shown in the following figures will be easily understood.

Figure 235 shows the method of connecting an instantaneous water heater by the direct system. The water enters the heater from A, the cold-water house supply, through connection C, and the hot water is delivered through connection D into B, the hot-water supply line to the house fixtures. In order to permit the shutting off of either the coal range boiler or the instantaneous heater, gate valves F and H are installed. Valve E is a check to prevent water passing back through the heater. G is the gas line.

Figure 236 shows the method of connecting an instantaneous water heater by the reheat system. The water enters the boiler from the cold-water supply line, A. F and H are gate valves and E a check valve. G is the gas line. F and the short connection on which it is placed between lines C and B, makes it possible to operate either the boiler alone or the heater in connection with the boiler, whether or not the latter is being heated by the water back. To operate the boiler alone, H should be closed and F opened. To operate the heater, H should be opened and F closed, in which case, it is seen that when a hot-water faucet on line B is opened, water will enter the heater from the boiler through connection C and will be discharged through connection D into line B and to the fixtures.

The advantage of the reheat system lies in the reduction of the amount of gas necessary to raise the water passing through a thermostatically-controlled heater to the temperature that will close the thermally-controlled gas valve. When applied to an instantaneous heater that is not thermostatically controlled, a higher final temperature is obtained than if the direct system is used.

Almost all of the operations described or referred to for connecting circulating water heaters, apply equally to heaters of the instantaneous type. A few additional instructions will now be given:

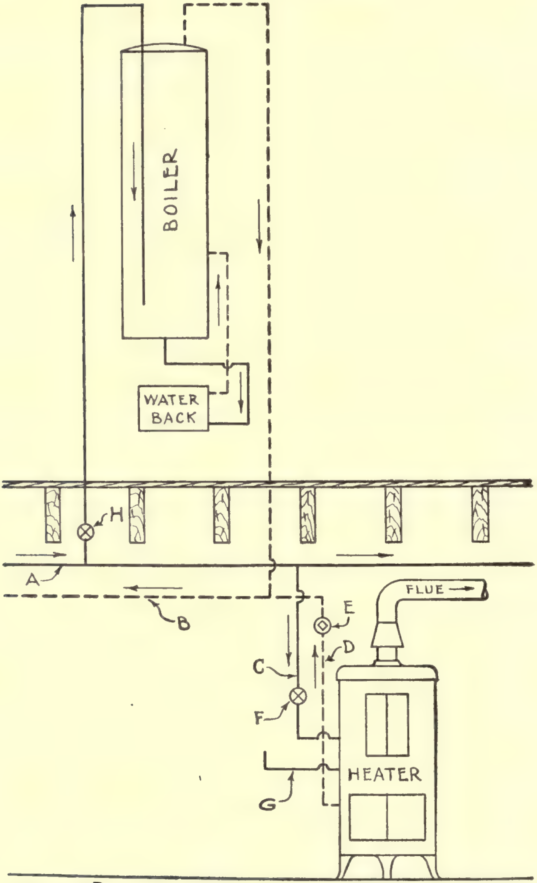


Figure 235.—Instantaneous Automatic Heater Connection—Direct[redacted] System, page 765.

The size of the water connections should be that indicated by the outlets in the heater. This usually will mean piping of size in the following table:

Heater Number	Size of Water Connections Inlet and Outlet Piping
2	¾"
2½	¾"
3	¾"
4	¾"
6	1"
8	1"

A firm foundation should be provided for the heater. A hard dirt floor is not satisfactory.

Every heater should be connected to a flue, according to the rules in Chapter LXIII.

If necessary to provide a drain to the drip pan or ring, such provision should be made by connecting direct to an existing drain, and not by breaking a cement cellar floor and inserting the drain pipe blind or with a "French drain" effect.

To prevent wasting hot water, the use of self-closing faucets at the points where most hot water will be used, is recommended.

The instruction tags furnished by the company or by the maker of the appliance, should be posted as directed, permanently and in a conspicuous place.

After all the connections have been completed, the fitter should completely fill the system with water and should test the heater for proper operation of the pressure and thermal valves.

All Other Types of Heaters

All the other heaters described in Chapter LXV fall in one of the above classes, for which connection details have been given.

Special mention may be made of the "furnace connection" method of heating water for domestic use. In this method, a bulb-shaped hollow casting, or a coil of pipe, or a combination of fittings, is placed in the firebox of the house heater, and there acts as a water back, being connected with the hot-water boiler by a simple return system. This installation is sometimes made by gas companies to provide hot water by other means than the coal range, and thus promote the use of the kitchen gas range during the winter. Where the kitchen would ordinarily

be heated by the coal range, a radiator is installed, shunted between the hot and cold furnace connection water lines.

In general, it may be said that such an installation is entirely satisfactory only when a good fire is maintained in the furnace. As continuous cold weather is necessary to insure such a fire, this method cannot be guaranteed in a winter climate where intervals of warm weather are likely to occur.

Records, Instructions and Cleaning Up

After all the connection work is completed, the fitter should inspect it, clean up, make the necessary records, and instruct the consumer, all as described in more detail in Chapter LXIII.

Subinspection

Subinspection of the installation of circulating and combination boiler and water heaters should be made in the manner described in Chapter LXIII. In the case of automatic or instantaneous heaters, it should include, in addition to the operations already described, a careful inspection of the special valves and an examination into the draught afforded the heater.

CHAPTER LXVII

MAINTENANCE ROUTINE

Reasons Necessitating Maintenance

As in the case of cooking appliances, water heaters are designed with the idea of affording maximum efficiency and satisfaction to the consumer, and at the same time, of reducing the number and cost of maintenance visits to a minimum. As complaints of water heater performance are more difficult to remedy than those of cooking appliances, it is essential that the men on the work be well skilled.

Tank Heaters

Adjustments and Leaks

The burner cock, air mixer and burner of the average tank heater are used less frequently than those of a cooking appliance, and they are free from the dirt caused by cooking materials. Therefore, it is comparatively seldom that they need adjustment. When this condition occurs, it is remedied as described on page 721. A source of burner stoppage that does not exist in a cooking appliance, is the deposit, resulting from incomplete combustion, that forms on the outside of the heater internal, drops on to the burner, and thence finds its way into the orifice and cock. Its removal is necessary for proper burner adjustment, but fortunately is easy. The internal should be cleaned of this deposit before touching the burner.

The burner of a tank heater should be adjusted to the proper flame when consuming the standard amount of gas for the conditions under which it is installed. When no flue connection is provided, the proper rate of consumption is from 35 to 40 cubic feet per hour, and with a flue, from 50 to 60 cubic feet.

Gas leaks should be repaired as told in detail on page 723. The construction of the burner and the mixer tube, fastened together, as they are, by a slip joint and set screw, affords a chance for a leak that does not exist with a cooking appliance

burner. The slip joint may be parted by a slipping of the set screw, or by force or weight applied accidentally to the gas connections, either at the heater or sometimes in the cellar. The remedy is to loosen the set screw, remake the slip joint, and, if possible, remove the cause of any permanent strain that tends to pull the joint apart.

The repair of water leaks in the connecting pipes, if this kind of work is undertaken by the company, means a renewal of the leaking pipe or fitting, or perhaps only the tightening of a thread, or the renewal of a union washer. The workman who preinspects this kind of work should make a most careful examination, not only of the leaking pipe, but also of all adjacent pipes or parts that will in any probability be disturbed by the work of repair. The external appearance of a water-carrying galvanized pipe or fitting may indicate it in good condition, while, in reality, it is but a shell that will be crushed or will otherwise fail by the touch of a wrench or by the application of the slightest strain. When leaks occur rather frequently in the iron pipe where it is screwed into the hot-water outlet of the heater, the trouble may be due to electrolysis of the iron pipe. The remedy is to use a short brass nipple in the heater outlet.

A water leak practically never can be repaired on the consumer's premises, and seldom can it be permanently repaired. This necessitates the renewal of the part complete. In some cases, the company allows a standard credit for the old part, which usually contains something that may be used over again, or that has a scrap value.

Miscellaneous Repairs

The design of the modern tank heater is so simple that repairs of a character other than those already mentioned, are limited practically to the replacement of broken parts, and this work is very easily performed. Complaints of insufficient hot water or of slow heating are not frequent, but when due to sources other than poor gas supply or improper burner adjustment, are often difficult and sometimes impossible to remedy. This remedy involves, first, an investigation for stoppages in the water system, and second, a removal of the stoppage. When the water supply from the street is sufficient, and is clean and free from constituents that, when heated, form new chemical combinations, with resultant deposits, stoppages usually occur only

within the boiler or the water back of the coal range, or in the pipes connecting the tank heater or the water back with the boiler.

With connections made as shown in Figures 229 to 231 the approximate location of a stoppage may usually be determined as follows: When the supply to the cold-water faucet in the kitchen is good, it is probable that the cold-water supply to the boiler also is good, thus indicating no stoppage in those pipes. When, under these conditions, the hot-water supply to the kitchen faucet, or perhaps to the whole house, is considerably less than that delivered at the cold-water faucets, it is probable that a stoppage exists in the hot-water line near its point of take-off from the boiler. When, under the same conditions, the water heated by the water heater circulates freely through the hot-water connection, and enters the boiler with the same freedom, it is probable that the stoppage is in the hot-water system beyond the point at which the hot-water connection of the heater is made. When the water heated by the gas does not ascend freely, but tends to back down into the cold-water connection of the heater, it is probable that the stoppage is either in the heater itself or in the hot-water connection, unless one of the previously mentioned tests has indicated it to be at some other point. These same symptoms may indicate, however, a stoppage in the cold-water supply to the heater, and, in many cases, this stoppage may be in the water back connections or in the water back itself. This kind of a stoppage can usually be removed by allowing the heater to burn for some time and then drawing off the water through the draw-off cock, or from any other draining outlet. This is the most common of all stoppages affecting water-heater performance, resulting from the fact that sediment naturally accumulates in the lowest parts of the water-carrying system. The remedy for stoppages at other locations usually will involve taking down the connections and renewing a certain portion. Just how far the company will proceed with this kind of work, is a question to be decided in each situation.

Another kind of trouble that results in insufficient hot-water complaints is due to "by-passing," so named for the reason that the water that has been heated is prevented from circulating in the intended way, and is either forced to mix with cold water or is by-passed by cold water when the hot-water faucet is opened. This trouble may be recognized by the delivery from the hot

faucet, of cold, or of alternate cold and hot, water, while at the same time the heater seems to be working properly. In some cases, this may be due to a partial stoppage, which results in the water drawn from the hot faucet passing directly through the heater without entering the boiler. This means that the water is following the path of least resistance, and it can be remedied by clearing out or enlarging the path through which the water is intended to travel, or by increasing the resistance to its travel through the water heater. This latter can be done by throttling or reducing the size of, or by inserting a number of elbows in, the cold-water connection. The mixing of cold water with that just heated is usually the result of the absence of, or a defect in, the cold-water boiler tube. This trouble can be fairly accurately diagnosed by the fact that the water is properly heated and circulates well up to the point of entrance to the boiler, at which point it seems to be suddenly cooled, thus preventing its storage in the top of the boiler. The remedy is to renew the tube.

A complaint of rusty or muddy water may be sometimes remedied by flushing the boiler in position; that is, by burning the heater for about a half-hour and then drawing off a considerable amount of water through the drain outlet. In other cases it is necessary to take the boiler down and give it a thorough flushing, and in still others, to renew the pipes that may be the source of rust. When the heater is an iron internal, the renewal of the latter may be necessary to remedy the trouble.

A complaint of a thumping, cracking, or hammering noise, which is due to a stoppage in the circulating pipes, should be cared for by a removal of the stoppage in the manner previously described.

Combination Heaters

Since there is no standard design of combination heaters, it is not possible to lay down specific rules for their maintenance. In general, complaint work on the burner, shell, internal, and water connections, follows the principles just laid down for tank heaters, although the troubles that are incident to the differences in design should be remedied in the manner that suggests itself to the trained complaint man. When one of these heaters is automatically operated, to the troubles already mentioned must be added those occurring with the automatic valve mechanism. Owing to its lack of standardization, no attempt is made to treat of the various troubles to which it may be subject.

Instantaneous Automatic Heaters

Adjustments and Leaks

The explanation of the design of the instantaneous automatic water heater makes plain the impossibility of adjustment, in the ordinary sense of the word, of the burners of the heater. The size of the air openings, of the gas orifice, of the burner gauze and of the burner ports, is fixed. It is important that proper gas supply be available for this type of heater at all times, and this being true, the only necessary burner adjustment will be a cleaning of the gauzes and burner heads. The importance of keeping the burner gauzes clean cannot be exaggerated. The usual location of the heater in the cellar where dirt and dust are prevalent, results frequently in dirty gauzes, which, in turn, mean complaints of gas leak, insufficient hot water, and of a high bill. Such a condition almost invariably causes a carbon deposit on the coils above the burner, and it is necessary in each case, when cleaning the gauze, to clean the coils also.

When the size of the pilot flame is too large and has caused a carbon deposit on its head, the carbon should be cleaned off and the flame adjusted. The proper length of this flame is about one inch, measured from the port to the end of the flame along the natural upward curve that the flame assumes. It is important that the pilot be always in the correct position, namely, close to one of the main burners and slightly above it.

It seldom is necessary to adjust the rate of water flow through the heater, or the temperature of the water. The directions for this adjustment in a typical heater are now given. To test the adjustment of the thermostat, which is adjusted at the factory to about 140 degrees, regulate the flow of cold water through the heater to its rated capacity by using an ordinary 3-gallon scrub pail and timing the flow. Then draw hot water at the faucet nearest the heater at the rate of one-half the heater capacity. The water temperature should now be 140 to 150 degrees, the gas going on and off intermittently. If it is too low, the regulating screw should be turned inward, and if too high, outward. A quarter-turn of the regulating screw usually makes a change of about 10 degrees in the temperature. When making the water flow adjustment, it should be remembered that leaking faucets or toilets will, in some cases, greatly reduce the initial pressure, and the consumer should be told that these must be repaired before a satisfactory adjustment of the heater can be made.

The only other possible adjustments additional to those already mentioned are some minor ones connected with the water and gas valves, and which cannot be satisfactorily described here, but are self-evident to the workman who is familiar with the heater.

The occurrence of water leaks in automatic instantaneous water heaters is limited practically to those in the copper coil. These necessitate the renewal of the coil in the same manner as described for tank heaters. Gas or water leaks in connecting pipes are cared for in the usual way.

Miscellaneous Repairs

Owing to the sturdy construction of this type of heater, it seldom is necessary to make repairs that would involve the use of material, other than the renewal of the burner gauzes and copper coils, that have been previously referred to. However, there are some troubles which occasionally arise in the operation of the heater and these it is well to describe and to tell the remedy. As with tank heaters the most common complaint is lack of sufficient hot water. In these cases the complaint man should first assure himself that the gas supply is ample, following the rules in Chapter LVII; also that the gas valve operates properly, that the burners are properly adjusted, and the coils free from carbon deposit. Then he should test the water pressure at various points of the house, and if this seems good, he should ask the consumer whether good pressure is maintained at all times of day. It occurs not infrequently that the trouble is due entirely to poor water pressure in the street or at the head of the service, and that this makes itself felt only during times of peak water load, either within the building or in the neighborhood. In certain cases it may be advisable to check conditions by setting a recording gauge for 24 hours. When the trouble is in the street, a pressure increase is beyond the consumer's power, and if in the service or the building, it is seldom that the consumer will approve the expenditure usually necessary. Under these conditions, the only way to effect any improvement is to install a water valve with a large piston area, or to replace the springs in the gas and water valves with weaker ones. Both of these methods are intended to reduce to a minimum the energy expended by the water in operating the heater mechanism.

Insufficient hot water may be caused by a failure of the water valve to open all the way, by the hot water outlet pipe being obstructed, by the existence of poor chimney draft, and by the improper operation of the water valves used on the connections.

When the pilot flame jumps out, when not due to insufficient gas supply, the cause may be the too rapid operation of the main water and gas valves. Intermittent burning or fluttering of the heater when no hot water is being drawn, may be due to an obstruction in the gas valve, or to the omission of the check valve on the hot-water line at the heater outlet.

When an excessive amount of water is condensed on the coils and drains into the drip pan and becomes a nuisance, it should be removed by installing a small drain pipe to a proper place of disposal.

All Other Types of Heaters

The maintenance of any other type of heater will probably involve no other principles than those already described.

SECTION IV

ROOM HEATING APPLIANCES

CHAPTER LXVIII

DESIGN

Introductory

Under normal price conditions, manufactured gas can seldom compete on a cost basis with coal for all year househeating purposes except in southern climates, but it is used very extensively throughout this country as a means of auxiliary househeating and wherever convenience is a particularly desirable consideration. However, in natural gas regions, househeating by gas is often cheaper than by coal, and the resultant demand for heaters has, as in the case of cooking and water-heating appliances, wonderfully hastened the development of satisfactory house and room heaters. These room heaters are now so inexpensive and, especially in the portable types, so convenient that they are bought each year by thousands of consumers of manufactured gas, and in times of extremely cold weather or of domestic coal shortage prove of great value.

There is such a continuing evolution in their design that only some of the more important examples of the various types will be described. The best practice in room heating is given from year to year in the appropriate committee reports to the former national gas associations, beginning with 1912, and their contents should be known by the student of this subject.

Classification

Nature of Location

A room heater may be classified in at least three different ways. First, with reference to location for which designed. A heater designed to be set out or moved about in a room is known as a

"portable" heater, because, subject to the making or unmaking of its connection, it may be taken anywhere. One of the conveniences and economies of heating by gas is this ability to move a heater from room to room, and it has been a determining factor in the prevalent use of flexible gas tubing, in spite of the many failings of tubing connections generally.

A heater designed for location in a fireplace is called a fireplace heater.

Principles of Combustion

The second method of classification is based on the principle of combustion employed. In the "blue-flame" type, the bunsen burner is used. The hazards arising with this burner from incomplete combustion have been discussed in Chapter LXII, in describing bunsen burners. For cooking food and heating water, or, in fact, in any operation where the flame impinges directly upon the article to be heated, the bunsen burner is necessary, but for room heating it is not essential, and, therefore, should not be used in any heater unprovided with a flue connection, with possible exceptions in the case of steam gas-radiators, or radiators of the incandescent or radiant types.

The "yellow-flame" heater makes use of a flame similar to that obtained with the ordinary flat-flame burner. The oxygen for combustion is obtained from the atmosphere surrounding the flame, which is free to extend into the combustion chamber until combustion is complete, and with careful design, there should be no chance for flame impingement and accompanying carbon deposit. In any case, such deposit would soon make itself known, so that the condition could be remedied.

There is no difference in efficiency between the two types, as the complete combustion of a cubic foot of gas will produce the same number of heat units, independent of the kind of burner.

Methods of Heat Utilization

The third basis of classification is with reference to heat utilization, and under it there are the following classes:

(a) Incandescent heaters, where the flame heats to incandescence, heating elements of refractory material.

(b) Reflector heaters, which directly reflect the flame radiation.

(c) "Gas" radiators, in which the combustion products pass through and heat a thin metal shell serving as a radiator.

(d) Steam or hot water radiators, which absorb the heat generated by the combustion of the gas, and radiate it in a manner similar to the ordinary steam or hot-water radiators.

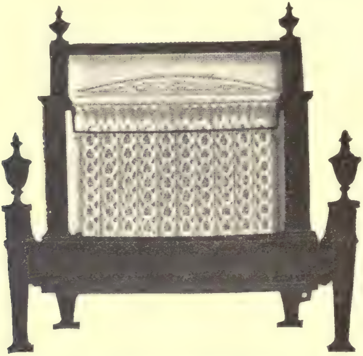


Figure 237.—Incandescent Heater.—Fireplace Type, page 778.

Incandescent Heater

The incandescent heater is of the blue-flame type. In the design illustrated by Figure 237, the incandescent effect is secured by the use of a number of tubes, or "elements," of ceramic material. Their sides are lacework with large openings. Each element is placed directly over a bunsen flame, and acts in a manner similar to the mantle of an incandescent lamp. Spuds, having fixed rectangular orifices, are provided, and there is no primary air regulation. The outside frame is made of cast iron with an oxidized brass or similar finish. A valve controls the gas supply to all the burners. This type of heater is designed for installation in a fireplace, where it presents a very attractive appearance, especially when lighted. Because of the intensity of radiation within a short distance from the heater, if the floor covering immediately in front is of inflammable material, it should be screened from the radiated heat by an extension fitted on the metal frame at the bottom of the elements.

Figure 238.—Incandescent Heater.—Portable Type, page 780.

Another type of incandescent heater is shown in Figure 238. Here the incandescing material consists of a cone-shaped, perforated sheet of cast iron. The drilled port bunsen burner is placed beneath the cone bottom, and the products of combustion pass up and out through the perforations. The body, or jacket, is a cylinder of sheet steel, clamped by long through rods between the top and base castings, in part cut away and for the rest perforated to allow the emission of radiant heat from the cone and the escape of the combustion products. This is a portable heater, and as such, competes for favor with the reflector and radiator types. Neither the form illustrated, nor another form of the reflector shape, in which the cone is visible, has met with any permanent favor. One objection is the odor which sometimes results from incomplete combustion, due to the impingement of the flames upon the cold metal cone when starting the heater.

Reflector Heater

The reflector heater was one of the first types on the market, but later on, for a time its popularity was subordinate to that of the gas radiator, due partly, no doubt, to the greater cheapness of the latter. More recently, however, it has returned to popular favor. It has to its advantage what may be called "'physiological' efficiency, the degree of which is dependent on the percentage of the total generated heat that is emitted in the form of radiant energy; and the room heater which attains a high physiological efficiency is more effective, not in heating the air of the room, but in making it comfortable for the occupants, than is the heater in which such efficiency is low." The same construction that enables this heater to throw a high percentage of its radiant energy on persons in front of it, also causes its yellow flames to be in sight from a wide range of positions, and there is thus added the pleasure always afforded by a fire glow.

Figure 239 illustrates a reflector heater. It consists of a rectangular sheet-iron box, placed on four legs, and having an opening in its front side, which usually extends to within several inches of the top and an inch or so of the bottom. This opening should be covered by a wire mesh or strap iron lattice guard, so that curtains, dresses or other such materials cannot come in direct contact with the burner flames. This guard should be easily removable should the reflector need cleaning. The back and sides are preferably made of one sheet, but in some cases

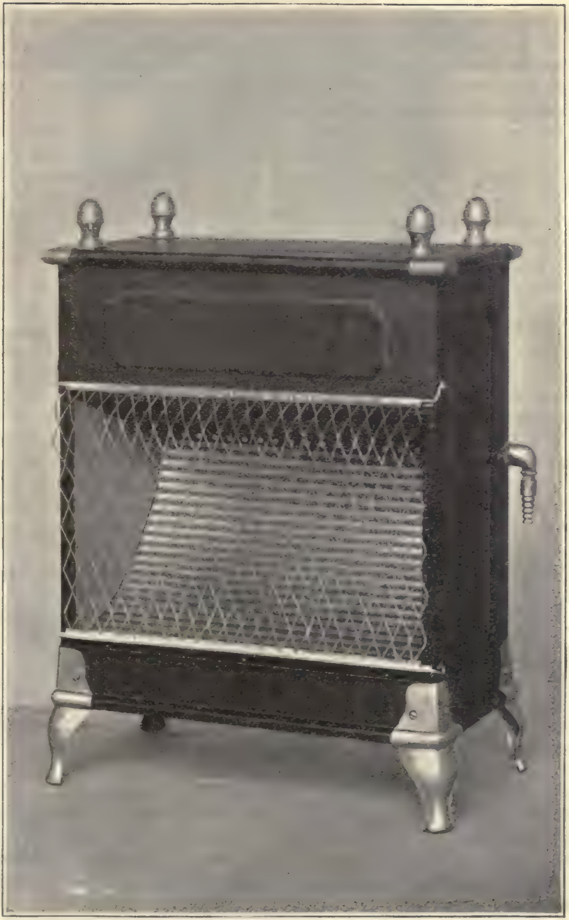


Figure 239.—Reflector Heater, page 780.

they are composed of three sheets folded together. The front of the box is made of two narrow sheets, one above and one below the reflector opening. The top plate usually has rolled edges, and is secured to the body by nickel or other fancy corner pieces and stove bolts with ornamental knobs.

The burner, which consists of a small pipe into which are inserted small burner tips, is about an inch longer than the width of the heater body, and is placed across the inside back of the heater at a point about level with the bottom of the top front sheet. One end of the burner, projecting through the heater side, is capped. The other end is equipped with a cock having a lug similar to a drop ell, bolted to the heater side, which holds the burner in proper alignment. A circular hole in the side sheet allows the insertion of a light for ignition. In designing the burner, its easy and prompt ignition, the evenness of the flames and their proper alignment, are points that must be kept in mind. Prompt ignition of all the tips along the burner is necessary; otherwise, there may be a considerable escape of unburned gas.

Starting at the burner and running down to the top of the bottom front sheet is an elliptical-shaped, corrugated copper reflector. In the best heaters, the side copper sheets are secured by being folded in with the body sheets, but in the cheaper types the sides are attached by what is called tacking. This is simply a drop of solder placed every inch or so. The entire reflector is attached to the bottom front sheet by stove bolts, and should be easily removable through the heater bottom without any bending.

A baffle extends upwards from the burner to within two inches of the front of the heater, and forms a compartment in the heater top. There is a capped flue collar in the back sheet, for use where flue connections are required. The bottom of the heater body should be reinforced by rolling over a round wire or a strap iron frame. In heaters made of aluminum, or those having ornaments which would tarnish with heat, the top and top front sheets have an extra lining and air space.

Gas Radiator

Because it resembles, in a general way, the well-known steam radiator, the name "gas radiator" has been given to the type of room heater shown in Figure 240. Another form of "radiator" has only one cylinder and is often known as a "round heater," Figure 241. Both shapes have yellow flames and no provision for flue connections.

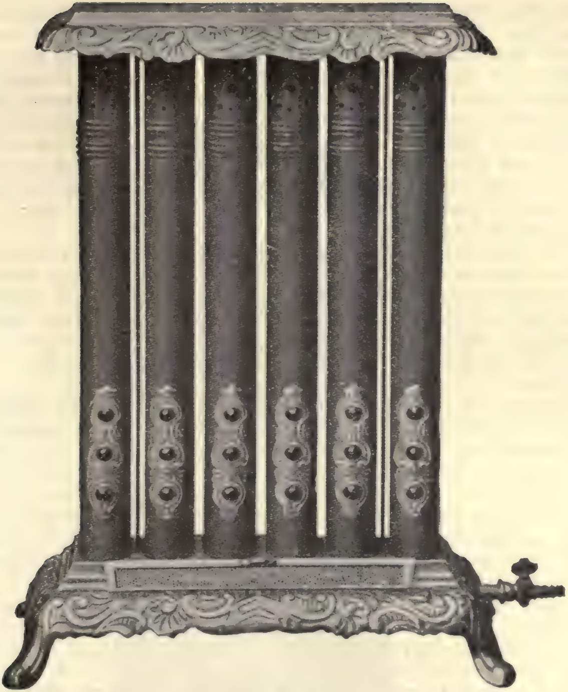


Figure 240.—Gas Radiator, page 783.

The burner of the multi-tube radiator, Figure 240, is ordinarily a half-inch steel pipe extending under and through the base casting. One end is equipped with a cock, and the other end is capped. The pipe is tapped to receive the burners, which are usually union Scotch tips, one or two being located under each tube. The hourly consumption per tube varies from 5 to 8 cubic feet at 2 inches pressure. Ignition is ordinarily accomplished by inserting a light through a slot in the base casting

extending across all the tubes, and the light must be applied to each tip. In one type of construction, a plate of sheet steel, known as a flasher or spreader, is attached to the door in the base and moves about the burner as an axis. The action of opening the door pulls the spreader over the burner, so that when a light is applied to any one burner, it flashes at once to all the others. The side of the radiator containing the slot is considered as the front, and by the interchange, end for end, of the cap and the cock on the burner pipe, the front may be always in the most convenient position, whether the gas supply comes from the right or the left.

The tubes are of thin sheet metal, cylindrical or oval in section, about three or four inches diameter. Openings around the circumference near the top allow the escape of the heated combustion products, and sometimes there are baffles above these openings. A sheet metal bottom is bolted or wired to the base beneath the burner, to prevent a dangerously high floor temperature.

The burner of the round heater, Figure 241, may be either a cast-iron, cored ring burner, varying from 4 to 6 inches in diameter, and containing from seven to eleven tips, or it may consist of a cast-brass or iron center hub, tapped to receive six or more brass tubes radiating from a center header and drilled with small orifices. The burner rests on an inside ring of the base casting, or is bolted to the base casting by projecting lugs from the ring burner, or, supported by a heavy piece of sheet metal, is attached to the base casting. The consumption of these burners varies from 20 to 30 cubic feet per hour at 2 inches pressure. The sheet metal body contains perforations, often of an ornamental design. The diameter of these bodies vary from 8 to 16 inches and the heights from 12 to 16 inches. A lighting hole is provided near the bottom of the cylinder just above the burner. The top may be either of nickel-plated cast iron, or of sheet metal, and is attached by rods extending through the heater to the base by through bolts or by welding to the body sheets.

The base is either of nickel-plated cast iron or of sheet metal. If the former, the casting generally consists of a ring, to which three or four legs are either bolted or cast. The diameter of these castings is from 3 to 5 inches greater than the diameter of the cylindrical sheet metal body. The legs attached to the base casting raise the heater several inches above the floor, which is protected from undue heating by a metal plate under the burner.

Figure 241.—Round Heater, page 784.

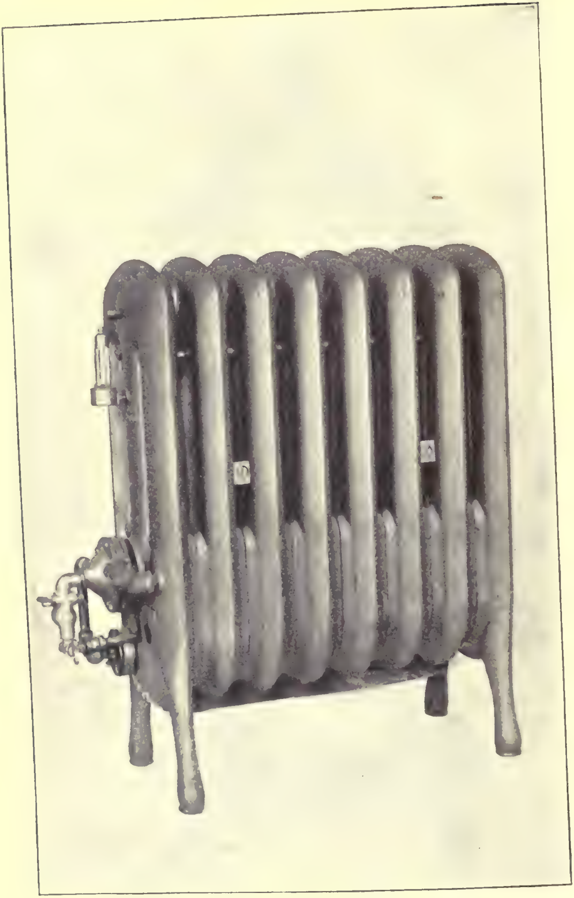


Figure 242.—Gas Steam Radiator, page 787.

Steam Radiator

In design and general appearance, these radiators, Figure 242, are similar to the ordinary steam radiator, being composed of a number of cast-iron or pressed steel sections, joined with push nipples and held together with through rods. Steam is generated from the water which is contained in the radiator base directly over the burner. The water content is rather small, being only one or two quarts.

The burner, which extends the length of the radiator, is usually of cast iron, and is placed at a distance of from $1\frac{1}{2}$ to 2 inches below the base in order to obtain good combustion.

The gas supply is controlled by a governor, the most common design being made in two sections, cup shape, about $2\frac{1}{2}$ inches in diameter, with a diaphragm of composition or of phosphor bronze. As the steam pressure increases, this diaphragm, which is connected to an automatic gas valve, slowly closes the valve. However, a by-pass insures a 50 per cent flow of gas to the burner at all times.

The radiators are equipped with automatic or manually controlled air valves, safety valves and filling cups. Water sight glasses are sometimes employed.

Fireplace Heater

The fireplace heater (with the exception of the gas log) is an adaptation for use in a fireplace of one of the portable types already discussed. When it is provided with a flue connection, most of the heat in the combustion products is wasted up the chimney. For that reason, and also to save the expense of providing a flue, there is sometimes a disposition to dispense with a flue connection, even when considerations of safety demand one. If the heater makes use of a yellow flame, the products of combustion are odorless and innocuous, and no flue outlet is necessary. On the other hand, the blue flame is, generally speaking, even more objectionable in the fireplace heater than in the portable type. This is due to the fact that to conform to the fireplace construction, the combustion surface must be set in a nearly vertical position, "and it is impossible to burn gas through ports in a vertical metal surface (where the flames issue horizontally) and at the same time secure perfect combustion. Each flame, as it issues, bends itself upward, and the upper portion of the flame licks against the metal surface, thus being cooled, and

delivering some products of incomplete combustion, with their accompanying odor."

"Another cause of incomplete combustion in these heaters is the vitiation of the secondary supply to the upper rows of burner ports; the products of combustion from the lower ports rise over

Figure 243.—Fireplace Heater—Yellow-Flame Type, page 789.

the face of the upper ports, so that the latter are compelled to burn the gas issuing from them in an atmosphere that is deficient in oxygen. In many heaters these effects are enhanced by the attachment of some noncombustible substance, like fibrous asbestos, on the face of the combustion surface; this material, introduced for the purpose of imparting a pleasant glow to the

heater, is an important factor in the prevention of complete combustion; it blocks the gas ports to a greater or less extent; it accumulates dust and dirt, still further blocking the ports; and it brings additional obstruction to the passage of secondary air to the flames. A careful inspection of a heater of this type in operation will frequently reveal an intermittent extinguishing and relighting of the small flames issuing from numbers of the ports."

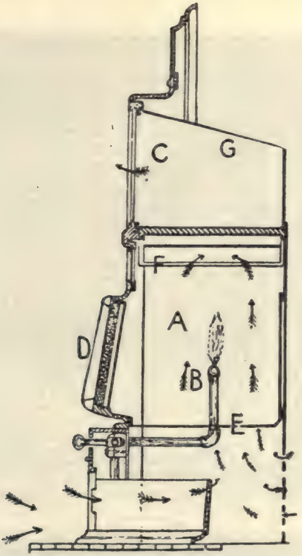


Figure 244.—Sectional View of Fireplace Heater—Yellow-Flame Type, page 789.

For the above reasons, as well as the possible back-firing at the air mixers, every fireplace heater unprovided with a flue should be of the yellow-flame type. Figure 243 shows such a heater and Figure 244 is a sectional view, indicating the flow of air and combustion products. When this heater is installed in a

fireplace with a flue connection, the air for combustion is partially drawn from the chimney at the back bottom part of the heater, the remaining portion of the air being drawn in at the front. A coal fire effect is obtained by encasing a layer of pieces of colored glass between the two transparent slabs. The upper part of the heater is of open design, to permit the escape of the products of combustion. The heater is also provided with a polished metal surface back of the burner to reflect some of the heat.

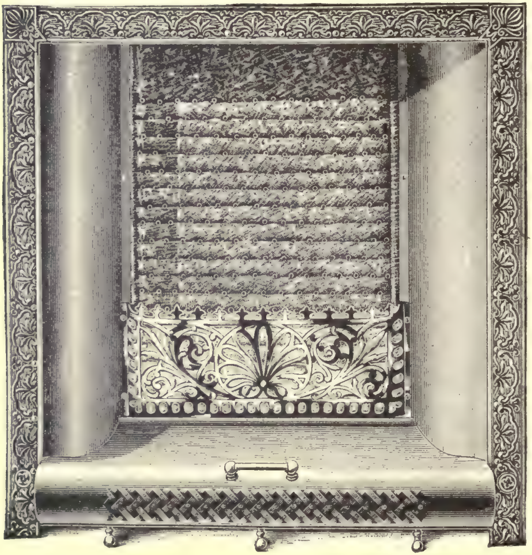


Figure 245.—Fireplace Heater—Blue-Flame Type, page 790.

When there is a flue connection, there is no objection to the use of the blue-flame type, and Figure 245 illustrates an asbestos front grate widely used.

Gas Log

The gas log owes its origin to the attempt to imitate the very attractive open-hearth wood fire. One, two or three sticks form the log casting, and the material is clay or cast iron, designed and colored to imitate real logs. In one construction there are passages connecting the hollow castings and each log is provided with gas ports. In another type, a cast-iron burner is concealed between the two logs, and the flame lights up the upper log only.

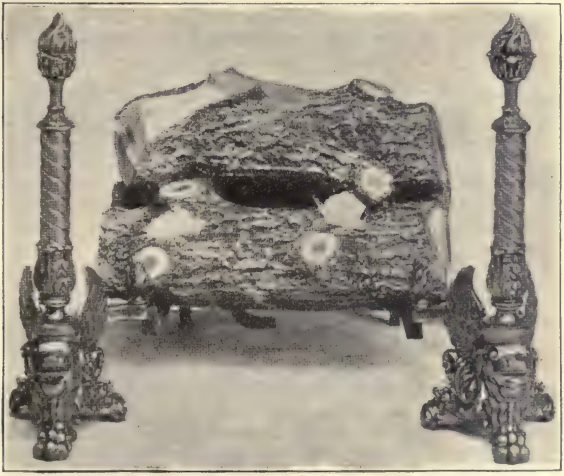


Figure 246.—Gas Log, page 792.

The first logs used yellow flames. There was continual trouble due to carbon deposit, which, besides being unsightly on the log surface, stopped up burner ports and allowed the escape of unburned gas.

The next step was a semi-blue flame, created by the use of an air mixer, furnishing an air supply insufficient to give a true bunsen flame. Trouble arose here because of the contamination by combustion products of the secondary air supply to the top

log. In many of these installations, as well as those of the yellow-flame logs already described, there were no flue connections, and the use of these logs resulted in many complaints and was distinctively unfavorable to this form of gas heating. Of recent years properly designed logs, Figure 246, have become available. Both the air and gas supply may be regulated to obtain a proper mixture. The passages or channels through the logs and the burner ports are suitably proportioned to the volumes to be transmitted. Such a log, with an adequate flue connection, will prove a satisfactory source of auxiliary heating.

Conditions of Use

Circumstances of Consumer

The moderate price of most portable gas heaters makes them available to any consumer. Where cost is the main consideration, the radiator is usually selected, but otherwise the reflector type, with its more cheerful appearance, is apt to be chosen. Fireplace and other fixed heaters are, as a rule, not found in inexpensive houses because of the comparatively high cost and high operating expense, but are growing in favor among the well-to-do.

Space Available

The fireplace heater would usually occupy space not needed for other purposes. Its use, however, as already stated, requires a flue and also is generally affected by other conditions much more important than the saving of space. The automatic gas hot water or steam radiator ranks next in the point of space economy, as these heaters take little room and then generally beneath windows where space is not of so much value. As a matter of fact, however, in small rooms, portable heaters are most often found, because in this class may be obtained heaters occupying the smallest amount of floor space and consuming the least amount of gas,—two requirements generally important to occupants of small rooms.

Character of Work

The size of a heater, either portable or fixed, will depend upon the duty required, this being a function of the space to be heated and, to a less degree, of the daily hours of use. The scientific calculation of size, where duty is known, is on the increase, and ensures satisfaction not attained by "hit or miss" methods.

One of the chief uses for gas heaters in dwellings is for general room heating in the late spring or early fall when the central househeating system is not in use. A portable heater best meets this demand. Another use is in a single room not provided with any other means of heating. For this, a fireplace heater would be preferable if there was a flue available and the higher operating cost was not objectionable; but generally a portable heater is used, though often with a fixed connection.

In offices, gas heaters are also used, both as auxiliaries to other heating systems and as the sole heat supply. In the latter case, the offices are apt to be very small or detached buildings where the low fuel cost of coal is more than offset by the comparatively high first cost of the coal furnace and the incidental trouble and dirt. For this service, the automatic gas hot-water or steam radiator is preferable because of the good temperature control. If out of use at night, however, they require a longer time to take the chill off than do the other types of room heaters.

CHAPTER LXIX

CONNECTION PRACTICE

Introductory

The connection of room heaters does not, except in very rare instances, require the visit of a preinspector. Therefore, the following description, as it relates to the workman, is written entirely from the standpoint that the first man who calls is equipped to perform the connection work. Also, as the general remarks in Chapter LXIII as to the consumer's wishes, the inspection of the appliance, shutting off gas, and gas supply apply equally well to room heaters, they will not be repeated here.

Location of Appliance

Consumer's Wishes

Because of the small size of room heaters, it is seldom that a location cannot be found acceptable to both company and consumer, and because of the prevalence of tubing connections, the consumer is free to change the location of the heater through a fairly wide range.

Fire and Other Hazards

Any fire hazard from a room heater will be avoided if the location, fixed by a rigid iron connection or made possible with a tubing connection, does not expose inflammable material to unsafe temperatures. Window draperies and wood finish are probably the most common sources of danger.

With tubing connection, a tripping hazard may be caused by a heater position which places the tubing line in the path of travel.

In Chapter LXVIII it was stated that, with certain few exceptions, no blue-flame heater should be installed without a flue. In small rooms with little or no ventilation, in which class bathrooms are almost always found, even a yellow-flame heater

may, over a period of time, vitiate the atmosphere by its products of combustion, and, therefore, such a heater of more than 25 cubic feet per hour consumption should not be connected in any such small room.

Connection

Iron Piping

In making an iron pipe connection, the workman should be governed by the principles laid down in Chapter LVI. When the connection is made from a side wall outlet with exposed piping, the line should drop directly from the outlet to the surbase and run along this to the point desired. If the heater is unprovided with a cock, one should be placed as close to the burner as possible, with a union on the heater side.

Tubing

The portable feature, which so largely contributed to the widespread use of room heaters, introduced at the same time a connection hazard through the use of flexible tubing. The ease with which a piece of tubing could be changed from one cock end to another, and the low price at which tubing was sold by outside dealers, made it inevitable that the large majority of room heaters would be tubing connected. The condition of these tubing connections has, of course, been always rendered still worse by the frequent changes from one cock to another. With the very poor quality of tubing that was sold, and the loose fit of the ends, caused by constant connection and disconnection, it was hard to say whether the tubing itself or the ends was the greatest source of gas leakage.

In one situation, for some years all tubing sold by the gas company was provided with threaded metal ends. One of these screwed on to the male thread of the cock at the heater. Into the other end was screwed the brass tailpiece of a union with thumb-head handles, which could be made gas tight by hand by the contact of its sharp metal edge upon a conical, soft metal seat on the independent cock controlling the gas supply to the tubing. With one of these independent cocks in every room in which the heater was needed, it was possible to move the latter with its tubing from room to room and make a connection better than anything yet devised. However, the connection was not as convenient as the slip end, and its cost was greater, so it did not

meet with public favor. Also, in the hands of consumers, the use of the soft metal seat did not result in an absolutely tight joint.

In other locations were tried other devices designed to make the connection between cock and tubing less liable to pull apart. Nevertheless it remained true that throughout the country most of the room heaters were connected by flexible tubing of poor

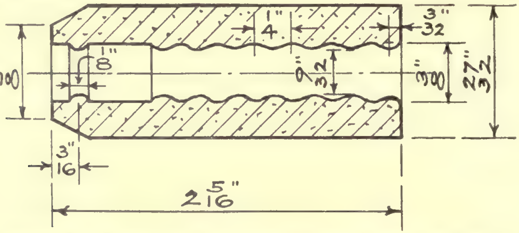


Figure 247.—Proposed Standard Rubber End, page 797.

composition and unsafe ends. It seemed as if the only solution for the protection of the public lay in legislation prohibiting any tubing connections. Fortunately, in 1912, there was produced a flexible tubing, which is superior in every respect to the so-called "rubber" tubing and also to the plain, spirally-wound, metal tubing. This tubing consists of a spirally-wound metallic base, packed with a threadlike rubber gasket. Upon this base is

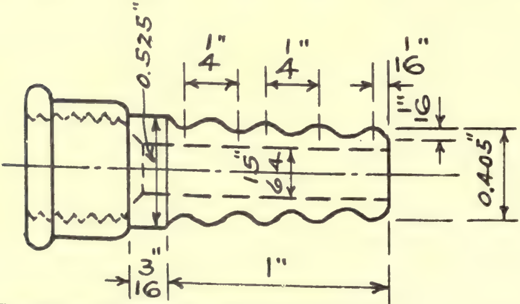


Figure 248.—Proposed Standard Hose End Nozzle, page 797.

wound coverings of paper, followed by cotton fabric coated on one side with a gas-tight compound, and the whole enclosed in an outer covering of cotton braid. Due to the quality and strength of its composition, this tubing is not affected by gas, is not readily ruptured, and is so stiff that it is not an easy matter to flatten it sufficiently to seal off gas flow. Brass ends, screwed into the metallic base, afford a secure attachment for the tubing ends. In all these particulars the old "rubber" tubing was very deficient. The paper and fabric coverings prevent the small leaks often occurring in the plain metallic tubing.

With the tubing and its attachments to its ends thus provided for, there still remained the problem of the grip of the tubing ends upon the hose ends of the cocks or piping. The shape of the contact surfaces has been the subject of much study by the gas associations, and Figures 247 and 248 represent what has been recommended for adoption as the standard rubber hose end and hose end nozzle, respectively. By the use of these designs and the new type of tubing, it is possible to enjoy all the advantages of slip-end tubing connections with none of the old objections. The need now is, possibly by legislation, but preferably by education of the general public, to reduce and, finally, entirely prevent, the sale of inferior, and therefore dangerous, tubing and attachments.

No tubing connection should be so made that the cock controlling the gas in the tubing is not within easy reach from the floor. The workman should inspect very carefully any tubing and its appurtenances both before and after installation.

Cock

The use and location of a cock on the supply line to a room heater formerly involved the consideration of two points: first, the ignition of the heater, and second, if tubing formed part of the line, the exclusion of it from unnecessary contact with gas. Taking up the first point, it has been generally considered that there should be a cock at the heater in order that it be possible to turn on gas flow with one hand while applying the light with the other. It was feared that if the only cock on the line were at the wall or fixture connection, the interval of time elapsing between turning on gas and applying the light would allow unburned gas to collect in the heater in quantity sufficient to make an unpleasant odor and also to form an explosive mixture, with more or less of a flash on lighting and possible danger to person. However,

tests considered as fairly representative of working conditions convinced the experimenters that the dreaded dangers were practically nonexistent, and could be considered absolutely negligible in comparison with the hazards introduced by the cock at the heater. These hazards arose from the fact that with a tubing connection, a cock at the wall or fixture was required in order that the gas might be shut off at that point. In this way unnecessary contact of tubing with gas (our second point above) was prevented, and this was quite important before the new tubing was available, as the other types deteriorated rapidly if exposed to gas continuously. Also, it was very essential, with the then existing slip ends, to avoid any unnecessary chance of gas escape should the tubing become detached at the wall end. Unfortunately, experience showed that with two cocks it was impossible, notwithstanding verbal and printed instructions, to prevent many users from keeping the cock at the wall open at all times.

In view of the above considerations, some of the larger gas companies omit the cock at the heater, and it would seem that this is bound to become standard practice. A special fitting at the inlet to the heater burner is threaded for iron pipe connections or for the attachment of the hose end nozzle, Figure 248. This nozzle should lie in such a direction as to prevent any sharp bend in the tubing at this point.

Where a tubing connection is made by means of an independent hose cock, to an outlet supplying gas for some other purpose,—usually a side bracket for lighting,—a hazard is introduced, due to the proximity of the cock on the outlet to the tubing, to the cock on the lighting bracket. With the two cocks close together, and their keys of approximately the same shape, experience has shown that it is possible for the heater cock to be turned on in mistake for the lighting cock and left on with the heater unlighted, even after the consumer has found it necessary to turn a second cock to get the desired light. To diminish this hazard, the keys of the two cocks should be as far apart as possible, and the cock for the heater connection should have a key of different shape, so as to be readily distinguishable, by the sense of touch, from the one controlling the light. As the usual fixture cock has the key beneath, the independent hose cock should be of such design that with the hose and nozzle vertically downward, the key will be on the upper side of the cock, and, therefore, 180 degrees apart from the fixture key.

Adjustment, Records and Cleaning Up

When the installation is complete, the fitter should inspect it, clean up, and make the necessary records, all as described in more detail in Chapter LXIII. The appliance should be adjusted, and, if necessary, the fitter should wait until the cessation of any fumes caused by the first burning off.

Instruction of Consumer

The consumer should be carefully instructed in the precautions as below for the various types of heaters:

> Yellow-flame heaters should be regulated by the cock on the appliance. When, as might be the case with a tubing connection, the gas is controlled by two cocks, both cocks should be shut when the heater is not lighted. When lighting, the cock furthest from the heater should be turned on first.
>
> When lighting gas logs or fireplace heaters of similar construction, the gas should be turned on full for about ten seconds before applying the match. This allows time for the expulsion of all of the air before lighting takes place and, therefore, prevents backfiring.
>
> No heater should be turned down very low, and there should be no bends or kinks in a tubing connection.
>
> Care should be exercised not to place portable heaters near inflammable material, or where a draft is liable to extinguish the flame.

Subinspection

A subinspection of heating appliance installations is usually thought unnecessary, except where the type is unusual or where some special reason for the inspection exists. However, a certain proportion of the installations should be subinspected as part of a general check on each man's work. When such an inspection is made, attention should be given to the quality of the work, also to the proper adjustment and operation of the appliance and to the satisfaction of the consumer.

CHAPTER LXX

MAINTENANCE

The design of a room-heating appliance is so simple that its maintenance requires but few visits and little resultant work. The adjustment of a "yellow-flame" heater is accomplished by reaming out or hammering up the fixed orifice spud, or by turning the screw in the adjustable spud. Proper adjustment means that the flames should be practically as large as possible, and at the same time complete combustion should exist, but no blowing, smoking, or flame contact with the heater parts. This adjustment should be made with the appliance cock fully open, so that the widest possible heating range can be obtained by manipulating the cock. The adjustment of a "blue-flame" heater is accomplished by regulating the supply of gas and air by means of the gas orifice and air shutter in the same way as explained on page 722. Adjustment of automatic control mechanism requires the special knowledge, by a good mechanic, of the principle of its construction.

Leaks in room-heating appliances proper are rare, and consist principally of cock leaks, remedied by tightening or greasing, of leaks at burners, which should be cemented or renewed, and of leaks at burner tips, which should be tightened, cemented or renewed. Complaints of odors that are thought by the consumer to be due to escaping gas, often are due to incomplete combustion, caused by wrong adjustment or flame contact with metal, to the absence of a flue or of proper draft, and to dirt, dust, or combustion deposit in or on the appliance. To be satisfactory, it is absolutely necessary that a room heater be odorless, and so it is very important for the workman who answers a complaint of this nature, to be competent and on the alert either to remedy the trouble or to advise the consumer of its exact cause.

Poor supply, when found to be at the heater proper, is due most frequently to obstructed burner tips or ports, which can be easily cleaned, and sometimes to obstructed orifices or cocks,

which should be cleaned as explained on page 722. Miscellaneous repairs consist of broken or worn part renewal, of general overhauling and cleaning, both of which are comparatively simple. Repairs to flexible tubing connections, made necessary by leaks or stoppages, should be accomplished in accordance with the thought that permanent repairs only should be made. In other words, split tubing and broken ends should be renewed and not taped. In many cases the defective part may be cut off, the end replaced, and a good, but shorter, length of tubing will be the result.

A complaint may be sometimes caused by the ignorance of the consumer as to the proper method of lighting room heaters, especially fireplace heaters and gas logs.

SECTION V

INDUSTRIAL APPLIANCES AND GAS ENGINES

CHAPTER LXXI

INDUSTRIAL APPLIANCES

Design

Preceding sections have contained a description of cooking appliances, water heaters and room heaters. All these types of gas-using appliances have been largely standardized, and such standard forms are met with so constantly in distribution work that they may rightly claim a place in a distribution manual. This is not the case with industrial appliances, of which the general statement is true, that each industrial use requires an appliance of special design. Because of this almost infinite variety in industrial appliances, their connection and maintenance are assigned to a special force of employees, and no attempt is made to train the entire fitting force in this regard. New designs are appearing continually, and to keep posted in the subject, one should be familiar with the "Salesman's Hand Book," Sections IX and X, and "Practical Educational Courses," as formerly issued by the National Commercial Gas Association, and also be a close reader of the gas journals and of the publications of the American Gas Association.

Connection Practice

The principles which should govern the connection of an industrial appliance have been given in detail in Chapters LX and LXIII. The fact that the design of these appliances is so varied as to preclude a satisfactory detailed treatment, makes it impossible also to treat the details of connections in any but a general manner. The preinspector should locate and measure for an industrial appliance and the fitter should connect it as demanded by its design, its principles of operation, and its

proposed use. The use of blast air, requiring a system of piping additional to those already spoken of, and the installation of a mechanical blower, does not greatly complicate the connection work. Nevertheless, generally speaking, the men directing and making the installation of all unusual types should be of the highest calibre available.

Maintenance Routine

Visits to maintain industrial appliances are made in the same general way as are those to maintain hotel appliances, as described in Chapter LXIV. The adjustment of the rarer types, or of those used for special purposes, requires considerably greater knowledge and a higher grade of man than the ordinary type of complaint man. The repair of leaks is much the same as that described for domestic appliances in Chapter LXIV, but miscellaneous repair work, often involving firebrick and sheet metal work, should be entrusted only to a trained expert.

CHAPTER LXXII

GAS ENGINES

Design

No description of a gas engine will be included here, because of the general familiarity with the internal combustion engine brought about by the widespread use of the motor vehicle; of the many existing treatises on gas engines, and of the small number of gas engine jobs compared to the total volume of distribution work. The reader is referred specifically to the "Salesman's Hand Book," Section IX, and to the "Practical Educational Courses," Lesson 17.

Connection Practice

General

The work preliminary to the installation and operation of a gas engine involves detailed plans of various kinds, including power calculations, shaft and machine locating, and other items of a more or less mathematical nature. The only work that will be here described is that necessary to the installation of, and the piping connections to, the engine proper.

It is desirable that the engine be set on a substantial foundation and that this foundation be placed where the engine vibrations will not be transmitted in any annoying or harmful way. The best location, therefore, is on the earth. The foundation should be composed preferably of a one-three-five mixture of concrete, should have ample bearing surface, and should extend well into the ground. When it is impossible so to locate it, and when it must be entirely above the ground level, it should be made correspondingly heavier to obtain an absence of vibration similar to that of the underground base. The anchor bolt heads should be well bedded and the shanks encased in pipe nipples, about $\frac{1}{2}$-inch larger in diameter than the bolt shanks, to allow for any slight movement necessary when placing the engine. The

concrete should be allowed to set for several days before putting the engine on it. After receiving the engine, the foundations may be made more sightly by filling in the depressions with cement grout and giving the whole a coat of cement plaster.

Antifluctuators

Before describing the necessary piping connections, it will be well to understand a most important feature of the gas supply system, namely, the method used to overcome the fluctuation in pressure that is produced by the sudden pull or demand for gas by the engine on its intake stroke. This fluctuation can make itself evident for varying distances from the engine, and when the proper compensating devices do not exist, it frequently affects the next door consumer, and when the system of mains is loaded to its capacity, or when a dead ended main exists, it may prove a source of annoyance at a point many hundred feet away. The antifluctuation devices that are used are varied in design, but similar in principle, which is, briefly, the provision of a chamber containing a quantity of gas, placed near the engine,

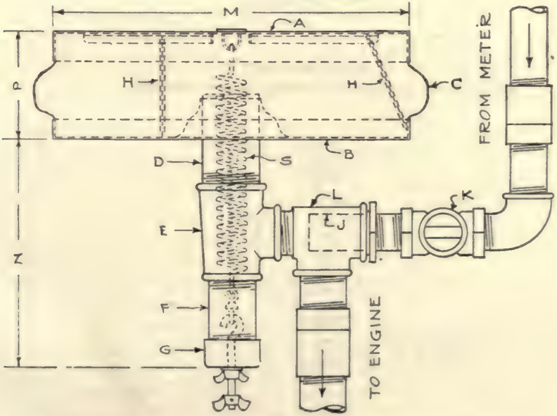


Figure 249.—Elevation of Antifluctuator—Method of Connection, page 807.

from which the engine will take the quantity of gas needed, so avoiding the momentary condition of a near vacuum in the supply line. Theoretically, the desired effect would be produced if the volume of extra gas thus stored was so large that the engine would require only a small portion, but practically, this would mean such a large storage tank as to be very undesirable. Consequently the storage principle is made more effective by the addition of a feature which automatically contracts or reduces the storage space simultaneously with the subtraction of gas from it by the engine. In other words, the tendency to vacuum is prevented, and so therefore is the fluctuation. Devices employing these principles in their operation take the form of a

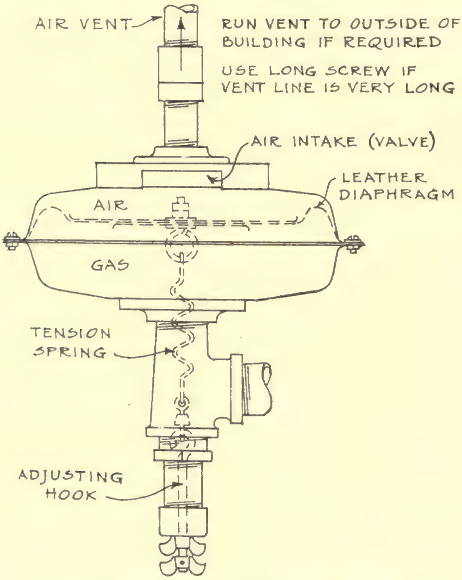


Figure 250.—Antifluctuator, page 807.

simple rubber bag, of a metal drum with rubber heads, of two metal cylinders working one within the other like a gas holder tank and lift, but with a glycerine seal and a spring tending to bring them together, and finally, of a device known as an antifluctuator, which embodies complete satisfaction with compactness and low maintenance cost.

Figures 249 and 250 show the types of antifluctuator employed successfully in Philadelphia. Several different sizes are provided for engines of different horse power, the largest being one capable of caring for a 50-HP engine. When large capacity is necessary, several antifluctuators may be connected in parallel. The general dimensions of the antifluctuator and gas connections are as follows:

ANTIFLUCTUATOR DIMENSIONS
(See Figure 249)

Antifluctuator Number......	1	2	3	4	5
Engine H. P....	Under 3	3–5	6–15	16–35	36–50
Dimension M ..	$8\frac{27}{32}''$	12 "	17 "	$23\frac{1}{4}''$	25 "
N ..	$8\frac{1}{2}''$	13 "	15 "	17 "	18 "
P ..	$3\frac{1}{4}''$	$4\frac{3}{8}''$	$5\frac{7}{8}''$	8 "	$8\frac{1}{8}''$
D ..	$1\frac{1}{4}''$x4"	2"x5"	$2\frac{1}{2}''$x6"	3"x7"	3"x7"
E ..	$1\frac{1}{4}''$x$1\frac{1}{4}''$x$1\frac{1}{4}''$	2"x2"x$1\frac{1}{2}''$	$2''\frac{1}{2}$x2"x2"	3"x$2\frac{1}{2}''$x$2\frac{1}{2}''$	3"x$2\frac{1}{2}''$x3"
F ..	2"x$\frac{3}{4}''$	2"x$\frac{3}{4}''$	2"x$\frac{3}{4}''$	2"x$\frac{3}{4}''$	2"x$\frac{3}{4}''$
J ..	$\frac{3}{4}''$	$\frac{3}{4}''$	1 "	$1\frac{1}{2}''$	2"
K ..	1 "	1 "	$1\frac{1}{4}''$	$1\frac{1}{2}''$	2"
L ..	$1\frac{1}{4}''$	$1\frac{1}{2}''$	2 "	$2\frac{1}{2}''$	3"

The antifluctuator in Figure 249 is composed of two circular, reinforced, round tin discs, A and B, connected with a leather diaphragm C, thus forming a collapsible cylinder. To disc B is soldered a pipe nipple, D, which is further extended downwards by the tee E, the nipple F, and the cap G. A spring, S, of which the tension may be adjusted, is connected between disc A and cap G, and tends to draw the two discs together. The action and the effect of the apparatus is as follows. When cock K is opened, the antifluctuator is filled with gas flowing through pipe J. At this time the whole supply system is filled with gas, not in motion, and with a pressure similar at all points. Under these conditions, spring S is extended to just short of the limit allowed by chains H. When the inlet valve of the engine opens, gas is sucked into the cylinder out of the antifluctuator through outlet of tee, L. This suction is so rapid that if the antifluctuator were a cylinder of constant volume, a tendency to

vacuum would be created, and a fluctuation produced in the gas pressure that certainly would be effective on any appliance connected to the same line of piping on the outlet side of the meter, and might be transferred through the meter and into the street mains. However, as gas is drawn out of the antifluctuator, and the pressure within it is decreased, the spring contracts, reducing the volume within the antifluctuator almost as fast as the gas is pulled out. Therefore there can be little inrush from the supply line and the pressure in the latter does not fluctuate to any harmful extent.

As a result of a demand from insurance interests for a more complete protection from leakage of gas through the leather diaphragm, an antifluctuator heavier and more costly than that shown in Figure 249 has been developed. It consists of a spun metal casing, preferably of soft steel, made in two parts of equal size. Figure 250 shows, in a general way, its construction. Practical experience with the simpler type has been entirely satisfactory, and it is to be hoped that its discontinuance may not be forced by an over emphasis placed on a danger that is only theoretical. The steel antifluctuator, except when very greatly oversized, produces an air bind that is detrimental to the operation of the disc. Its dimensions are approximately the same as those already given for the other type.

Gas Piping

The gas engine preferably should be supplied by an independent line from the meter, and to make doubly sure that no trouble from fluctuation will exist, no other consumption should be taken from this line. The following table shows the proper size of line to install for lengths of 100 feet or less. Greater lengths should be determined by the computer, allowing a loss of pressure of 0.2 inches through the total length. A fair consumption figure to use is 20 cubic feet per horse power per hour.

Gas Piping for Gas Engines

Engine Horse Power	Pipe Size
1— 5	1 "
6—10	$1\frac{1}{4}$"
11—15	$1\frac{1}{2}$"
16—35	2 "
36—60	$2\frac{1}{2}$"

Water Piping

The cooling water for the cylinder jacket is supplied either from a tank, so connected that the water will circulate naturally between the cylinder and the cooling tank, or directly from the street main into the cylinder, and from the cylinder to a drain. When the latter method is used, a break or gap is left in the vertical line leading from the cylinder, at which point the water may be felt with the hand, and the rate of flow properly adjusted. At the lower end of this gap, which is about 2 inches long, is placed a large reducing socket to catch the water flowing or spilling from the end of the smaller pipe at the upper end. The proper size of water piping is shown in the following table.

Water Piping for Gas Engines

Engine Horse Power	Tank Supply		Street Supply	
	Inlet	Outlet	Inlet	Outlet
1—2	$\frac{3}{4}$"	$\frac{3}{4}$"	$\frac{1}{2}$"	$\frac{3}{4}$"
3—10	1 "	1 "	$\frac{1}{2}$"	$\frac{3}{4}$"
11—15	1 "	1 "	$\frac{3}{4}$"	1 "
16—30	$1\frac{1}{4}$"	$1\frac{1}{4}$"	$\frac{3}{4}$"	1 "
31—40	$1\frac{1}{2}$"	$1\frac{1}{2}$"	$\frac{3}{4}$"	1 "
41—50	$1\frac{1}{2}$"	$1\frac{1}{2}$"	1 "	$1\frac{1}{2}$"

Exhaust Piping

The function of the exhaust system is to reduce the noise and to carry off the gases. Its proper installation is only secondary in importance to that of the gas line and antifluctuator. So that no back pressure will be exerted to reduce power and to decrease engine efficiency, the exhaust pot, or other muffling device, should be placed fairly close to the engine, and from there the exhaust line should be run with as few bends and as short a length as practical to the outside. Horizontal runs should be avoided if possible, but if unavoidable, a larger size of piping should be used. A straight vertical run to the roof of a building of ordinary height is to be preferred. The size of the line should be never less than the engine outlet, and when its length is over 25 feet, the size should be increased, and the whole tendency should be to make the line over, rather than under, size.

Maintenance Routine

The maintenance of a gas engine involves a certain amount of attention to its mechanism and a relatively small amount to the

gas supply. While in some instances the gas company maintains a force of repair men capable of attending to the mechanical adjustments and repairs on the engine proper, this kind of work frequently is attended to by mechanics in the employ of the consumer, or by the local agent for the particular make of engine. No attempt will be made here to describe the details of such work, because if the reader is sufficiently interested to investigate in other treatises, the details of gas engine design, he will obtain knowledge also of the details of adjustment and repairs. From the standpoint of the gas company, it is necessary only to maintain the supply system free from leaks and causes of insufficient supply, as explained in Chapter LVII.

SECTION VI

ILLUMINATING APPLIANCES

CHAPTER LXXIII

DESIGN

Introductory

Gas was introduced as a lighting medium and for seventy-five years it was preeminent in the field, although for a long time after the introductory years there was little improvement in the burners used. However, following closely upon the advent of electricity as a rival illuminant came the discovery of the incandescent gas mantle. Its development and perfection have provided gas lighting units as far superior to the old "open" or "flat-flame" burner as the latter was superior to the whale oil lamp or the candle.

Space does not permit further reference to the open burner than to chronicle its passing, which has progressed to such an extent that the old candlepower requirements or standards are giving place everywhere to the calorific standard as the proper measure of the usefulness of a product that is most efficient when used in a bunsen burner. As the incandescent gas lamp makes use of a burner of the atmospheric type, the principle of which is described in Chapter LXII, the only further description necessary is confined to the structural details of the burners as adapted to lighting units, and these will be given in describing each unit. These details of design and construction, as will be later apparent, are of great importance, and determine the success or failure of the burner. This follows from the fact that the illumination of the incandescent burner is derived entirely from the incandescence of the mantle, and in turn this incandescence is attained in perfection only in so far as the flame volume is contained within,

and coincides in shape with, the mantle. This, as the preceding chapters have shown, is an entirely different problem in burner construction to that presented by a cooking or heating appliance. The newest types of incandescent lights bear witness to the success that has attended years of patient and brilliant effort given to its solution.

However, for a satisfactory incandescent lamp, not only a good burner, but also a mantle of proper composition and durability is needed. Long after the proper mixture of thorium and cerium was known, the fragility of the mantle was an almost insuperable bar to its commercial use. The first mantles were formed by saturating cotton "stockings" with a solution of thorium and cerium salts and then burning off the cotton. By the substitution of an artificial fibre, the problem was solved, and a life of 2000 hours is a conservative average for the best grade of modern mantles.

Small Units

Upright Light

Burner

The first type of burner to be adapted to the incandescent mantle, and for years the only type in wide use, was what is now known as the upright burner. This form was a perfectly natural evolution from the flat-flame burner, and the resultant light was such a great improvement over that furnished by the gas burners previously available that, in the beginning, quantity production was of more importance than further improvements. These improvements came in the process of time, and in general may be divided into two classes, the first relating to the burner as a connection between the fixture and the glassware and as a supporter of the latter. Along this line the ingenuity of the workers in brass, both stamped and spun, was equal to the tasks assigned.

The second class of improvements was concerned with obtaining a more perfect admixture of gas and air, and a more convenient regulation of the varying quantities of each constituent needed for the perfect mixture under different conditions of gas quality and pressure. The mixture was affected by the shape of the conducting passages, as well as by the position and form of the gas orifice and air inlets.

Figure 251 shows in vertical section the latest development of the upright burner. The gas enters the mixing chamber, A, in the base of the bunsen tube through the passage, B. It may also enter through the slots, C, in the top of the bunsen base,

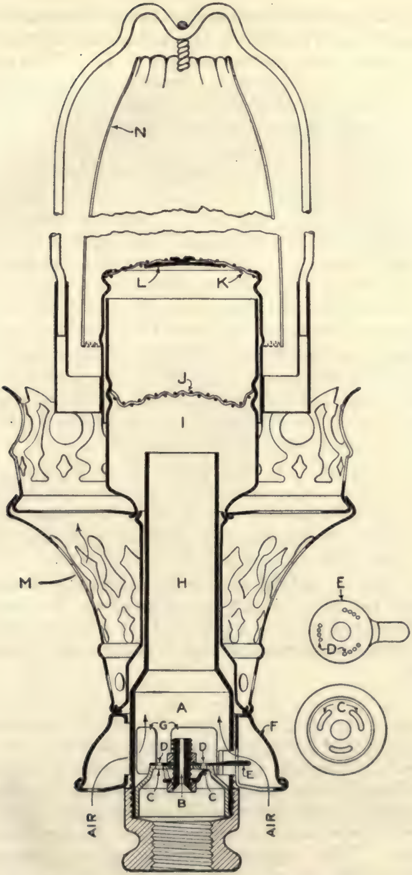


Figure 251.—Upright Incandescent Gas Light Burner—Vertical Section, page 812.

the amount so entering depending upon the number of slots uncovered by the perforations, D, in the disc, E, rotated by the cap, F, that covers the primary air ports, G. This combination of rotating with fixed openings results in a very dependable "multiple orifice gas control" and makes the burner instantly adaptable to gas of varying pressure and quality. The air ports themselves are fixed openings.

The primary air reaches the mixing chamber as indicated by the arrows. In its passage through the bunsen tube, H, it mixes intimately with the fine jets of gas issuing from the multiple orifice. The mixture expands into the burner head, I, passes through a coarse gauze, J, and finally reaches the finer gauze, K, of the mantle cap. This last gauze has a disc spreader, L, centered to the gauze, and this forces the mixture, and hence the flame, out toward the inner surface of the conical mantle.

In this, as in the other burners to be described, the gauzes have a dual function. The most important is to prevent back-firing, i. e., igniting at the gas orifice, especially at the moment of lighting. The second is to reduce the noise, which tends to become troublesome as gas pressure increases.

The secondary air required for the complete combustion of the gas in the bunsen flame reaches the mantle through the openings, M, in the gallery base, or, in the case of "side-hole glassware," through openings at the base of the chimney, as shown in Figure 252.

Although this is one of the most successful burners of the upright type, the light is not distributed as favorably as from other types, nor does the lamp lend itself as well to use on existing fixtures. For these reasons, the burner is rapidly being superseded.

Mantle

The standard mantle, N, Figure 251, for the upright burner is $3\frac{1}{2}$ inches long, has an average diameter of slightly over 1 inch, and has a somewhat tapering form from the mantle cap to the top. Its greater length, as compared with other modern mantles, involves a greater area and so makes more difficult the necessary coincidence of flame and mantle surface required for complete incandescence. This follows because correct burner design, uniform gas quality and pressure, and correct gas and air mixture are essential to bring about the ideal condition where the zone of combustion conforms to the surface of the mantle; and a given

variation in the above gas requirements will cause a greater displacement of this zone in a large mantle than in a small one.

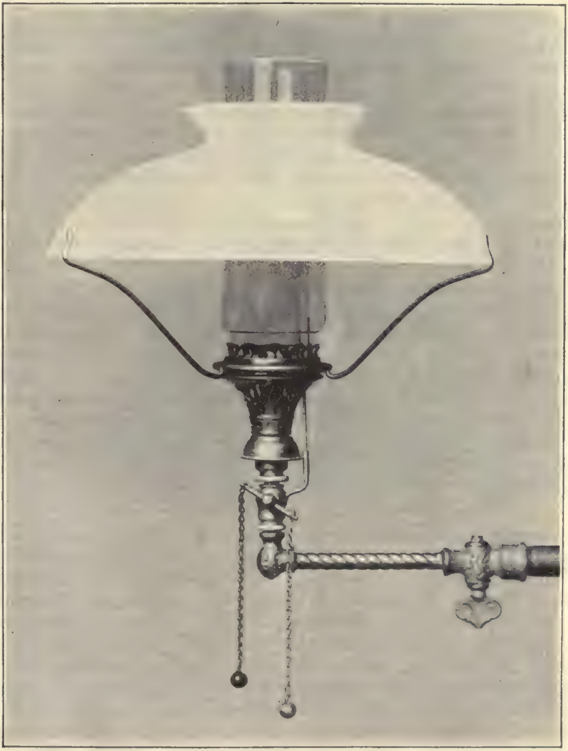


Figure 252.—Upright Incandescent Gas Light, page 814.

To preserve the desired coincidence of flame with mantle, the latter as much as the former must be kept from changing position.

The correct position is a vertical one, because the flame tends to assume a vertical position even though the burner may not be vertical. Faulty fixture design often makes impossible a vertical burner position, and this results in decreased initial illumination, followed by a breaking up of the mantle as its skirt rubs back and forth over the edge of the burner during the expansion and contraction following heating and cooling. In course of time that portion of the mantle around the burner top will drop off and then the mantle will swing on its top support and assume a vertical position. When the burner is at an appreciable angle from the vertical, this change will force the mantle so far out of the flame as to effect a marked reduction in illumination.

Even where the burner position is always correct, the maintenance of the upright mantle in a vertical position to the end of its useful life may still be very uncertain because of the difficult problem of its support. It has been supported variously by resting a cross strand of a supporting ring on a notched central standard, or upon appropriately formed single or double side standards. These standards, in the course of development, have been formed of steel wire, nichrome wire or clay-magnesia material. The supporting ring itself was for some time made of platinum, but finally of asbestos. The deterioration of strands or standard under the intense heat has always tended to limit the useful life of an upright mantle to the life of its support. The maximum horizontal candlepower available is 120, with an hourly gas consumption of 6 cubic feet.

Glassware

It is not the purpose to cover the field of glassware as applied to lighting burners, but merely to note how the particular design of each burner affects glassware. It has already been mentioned that a chimney is essential to the upright mantle, and herein lies another weakness of the upright light. Any departure from the vertical of burner or mantle involves excess of heat on one side of the chimney, and as the mantle ages or suffers from its incorrect position, the menace to the chimney increases, with the usual final result of a broken chimney, if it is of glass, or ruined surface if of mica. Often the breaking of a glass chimney causes the destruction of a mantle still in very good condition. A common shade equipment for the upright light is shown in Figure 252. This shade has the disadvantage of adding appreciable weight to the fixture, and because of the unsubstantial construction of many existing fixtures on which the upright

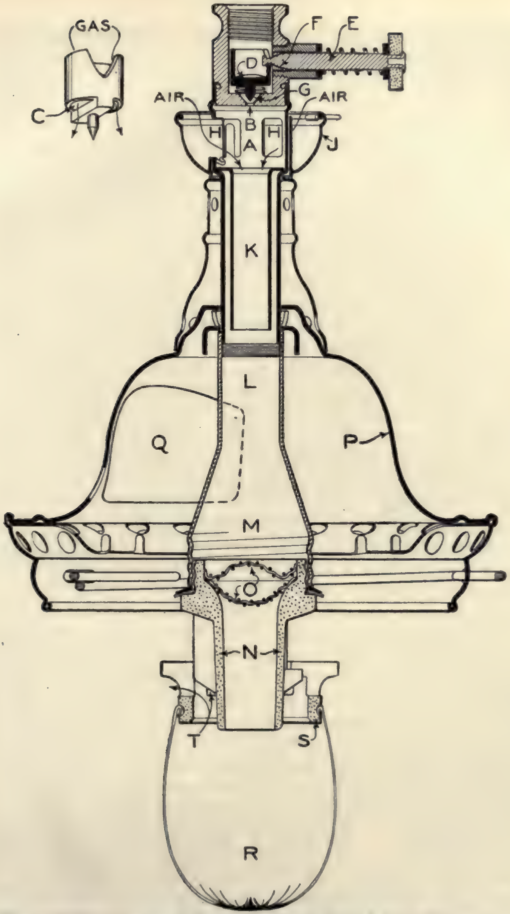


Figure 253—Inverted Incandescent Gas Light Burner—Vertical Section, page 818.

lights have been installed, the resultant sagging accentuates the departure of the light from the vertical.

Inverted Light
Burner

About 1903, the type of burner shown in Figure 253 was developed. Its name, "inverted," describes the radical innovation it introduced in the downward projection of the flame. This permitted an unobstructed flow of light downward,—the usual direction of required maximum illumination. As will be later described, the lamp also possessed other advantages over the upright form, which, therefore, it rapidly replaced.

Because the inverted light requires the gas and air stream to move in a direction opposed to its natural upward flow, a burner design was essential which would utilize the energy of the gas stream to entrain air and force the mixture downwardly. This, a problem of no mean proportion, was solved by giving close attention to the design of the portion of the bunsen tube just below the air ports. In a general way, this tube modification consisted in introducing a constriction so that the mixed gases would first flow through a tube of large diameter, then through a tube of smaller diameter, and finally into a mixing tube or chamber of larger diameter. The proper proportioning of these tubes immediately gave an increase in the efficiency of the device.

The downward direction of the air and gas stream naturally increases the tendency to back-fire. In the earlier forms of the best inverted burners, the difficulty was overcome by a very ingenious device known as a thermostat, located in the lower section of the bunsen tube. The thermostat when cool was shaped like a cone with very small openings at the apex between the fingers, or strips of metal, of which it was composed. Hence, there could be no great entrainment of air until, with the heating of the burner, the expansion of the fingers changed the shape of the thermostat into a cylinder with wide open end. In the latest development, the thermostat has been replaced by gauze in a tip of the widened inlet, fitted to a mixing chamber shaped for attachment of the tip. The widening also reduces noise.

Referring specifically to Figure 253, gas enters the mixing chamber, A, through the orifice, B, which it reaches through the openings, C, in the base of the cylindrical part, D. These openings are clearly shown in the large scale perspective view of D, to the upper left of the main figure. The gas flow through B is regulated by rotating the screw, E. As this screw moves

Figure 254—Inverted Incandescent Gas Light, page 822.

inward, the lower portion of its conical surface, F, moves into an opening in the side of D, and in so doing forces D downward, and this motion may be continued until the conical projection, G, has entirely closed B. As the screw, E, moves outward, the coiled spring under D lifts the latter.

In the mixing chamber, A, the gas meets the primary air entering through the openings, H, in the air shutter, J. The width of these openings is regulated by rotating the shutter. The mixture then moves down the constricted portion, K, of the bunsen tube. Getting hotter as it advances, it expands in the under portion, L, and still more in the tip, M. Into M screws the clay burner tip, N. It contains two gauzes, O, which are material aids in forming a perfect air and gas mixture and in preventing the flame from flashing back up the tube. After passing through O, the mixture flows down through the burner tip, and burning from its lower end, is forced down and out against the mantle surface, meeting there the secondary air which rises through the opening in the bottom of the inner glass cylinder. Attached to the burner structure is the dome, or crown, P, designed to permit the escape of products of combustion through vents, Q, on one side and thus to direct them away from the air ports. This dome also serves as a support for glassware. It will be noted that above the dome are annular vented spaces surrounding the bunsen tube, K, designed to reduce as far as possible the heating of this tube through contact with the upward passing combustion products. The dispersal of these combustion products in such a way that they have the least possible contact with the burner structure, has always been a problem in connection with the inverted burner, and the impossibility of a completely successful solution has resulted in tarnished metal and in pilot by-pass troubles, which have been arguments in favor of an improved form of upright burner.

Mantle

The inverted mantle, R, Figure 253, is about $1\frac{3}{4}$ inches long and $1\frac{1}{2}$ inches in diameter. It is mounted on a clay-magnesia ring, S, with extending legs that drop into slots in the burner tip, N. With the mantle in position on the burner tip, there is an annular opening, T, between the tip and ring for the escape of the products of combustion. Mantles of this type are commonly designated as "open top," to distinguish them from mantles which have no annular opening, and the only exit for the products is through the meshes of the mantle.

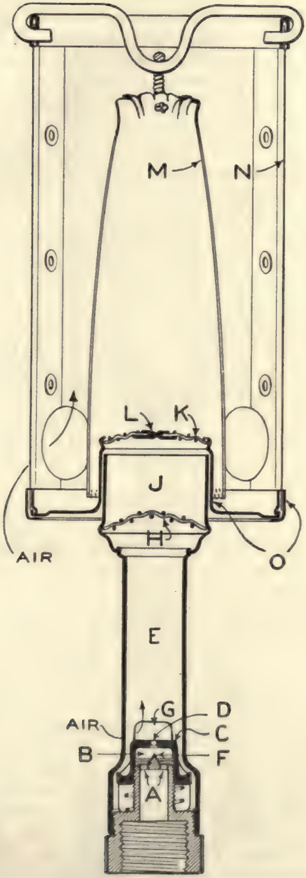


Figure 255—Junior Incandescent Gas Light Burner — Vertical Section, page 822.

The inverted mantle presents no problem of support and is largely independent of fixture position. Like the upright mantle, however, it requires a chimney, and as a result mantle troubles often cause chimney troubles, and vice versa. Its horizontal candlepower is 100 and the hourly gas consumption $4\frac{1}{2}$ cubic feet.

Glassware

The inverted burner needs two pieces of glassware. One is the chimney, or inner glass cylinder, seen in Figure 254, by the breaking away for this purpose, of a portion of the outer globe. This cylinder is provided with three nibs on the top edge, which are supported by an inner rim of the burner structure. Air holes around the base of this inner cylinder admit and direct secondary air to the mantle surface.

The second piece of glassware is the outer globe, and it is available in many varieties of shapes and materials. One common type is constructed of diffusing glassware, spherical in shape, through which the mantle itself is not visible, the lamp taking on the appearance of a uniformly incandescent sphere of light. Other shades are of various shapes designed to reflect or diffuse the light as may be desired for specific purposes.

Junior Light

Burner

The "Junior" light is a very simple and successful modification of the upright light. It was the first attempt to design an incandescent burner which could be substituted for a flat-flame burner without changing the existing glassware, and it still has a proper field of use in bathrooms or other rooms containing small floor space. Referring to Figure 255, gas passes through the two openings, A, into the space, B, beneath the milled cap, C. The gas flow through the opening, D, into the bunsen tube, E, is conveniently and satisfactorily regulated by the position of the cap, C. As this is screwed down, the conical projection, F, enters the opening, D, and the motion may be continued until the flow is entirely shut off. The primary air reaches the bunsen tube, E, which serves as the first mixing chamber through two openings, G, cut into the side of the tube. These are very clearly shown in Figure 256. The mixture of gas and air rises in the tube, E, is more intimately mixed by passing through the coarse gauze, H, and then expands into the enlarged top, J. A further aid towards a perfect mixture is given by the finer

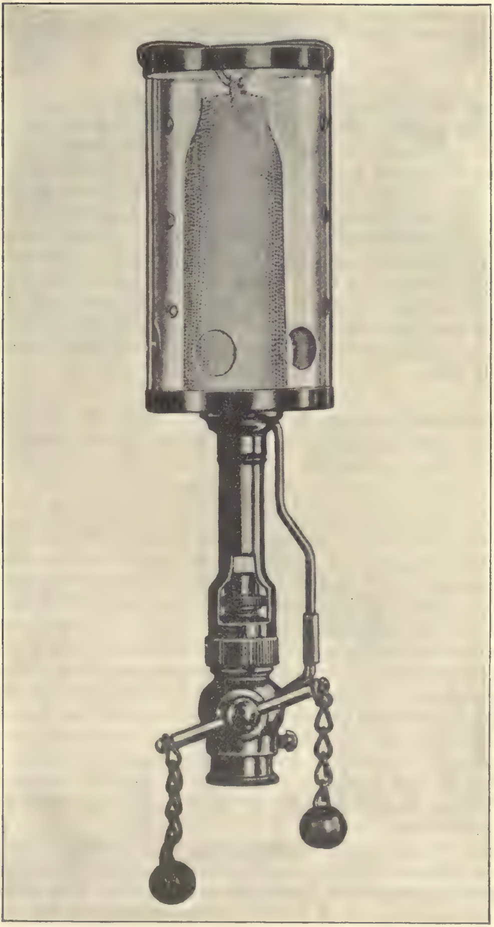


Figure 256.—Junior Incandescent Gas Light, page 822.

gauze, K, forming part of the mantle support and provided with a small circular plate, L, to deflect the flame to the surface of the mantle, M.

Mantle

As sold and used, the mantle is assembled with a mica chimney, N, provided with a metal base, O, which fits over the enlarged top, J, of the bunsen tube. The mantle itself is about $2\frac{1}{2}$ inches long and $\frac{5}{8}$-inch diameter. It is suspended by a loop from a wire mounted in the top frame of the chimney, N. The latter is $3\frac{1}{2}$ inches long and $1\frac{1}{2}$ inches in diameter, with holes at the base for secondary air. It is apparent that the substitution of a new "Junior" mantle for an old one is a very simple operation and more easily done than in the case of the upright or inverted mantle. This is another reason why the "Junior" light has been very successful in the hands of the gas user. The horizontal candlepower is 50 and the hourly gas consumption 2.5 cubic feet.

Glassware

As previously stated, the "Junior" light has no distinctive glassware, but is designed so as to be usable with many existing types of globes or shades.

C.E-Z Light

Burner

The "C.E-Z" light, developed in 1913 and sold in quantity since 1916, marks the latest development in the small unit incandescent light. It is the result of an unwearying endeavor to obtain a mantle light small in size and one which would not require the use of a chimney of any kind. It was known that success depended on the design and dimension of the bunsen tube in order to obtain the requisite entrainment of air volume for a given gas flow. The burner has the added advantage of adaptability to a variety of glassware, and because of its relatively high illuminating power is adequate for the ordinary room space. In a remarkable degree the burner adapts itself automatically to variation in gas pressure and quality, and this results, among other things, in a minimum of carbonized mantles. Its operation is noiseless.

Figure 257 shows the burner in vertical section. The devices for the regulation of the gas and primary air supply are similar to those already described for the inverted light. The constriction in the burner tube at A is followed by the upwardly expanding

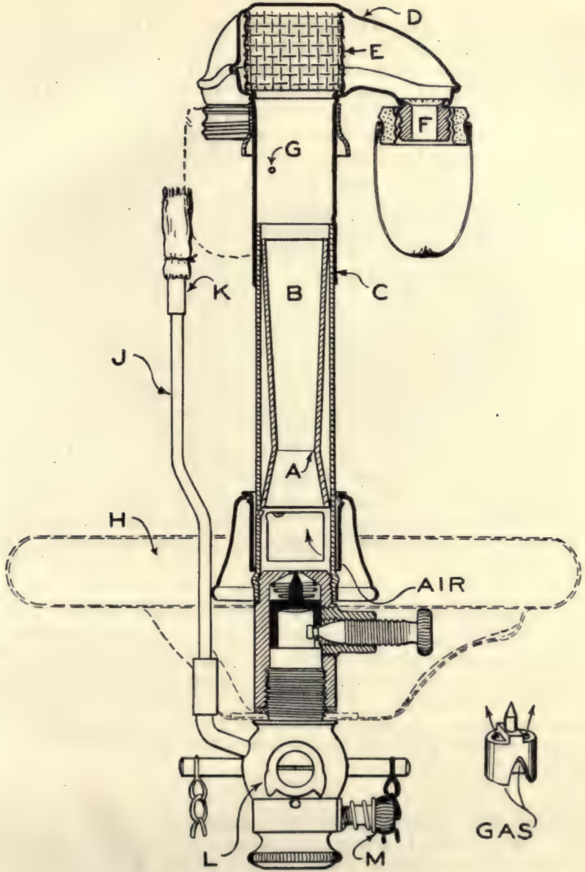


Figure 257.—C. E-Z Incandescent Gas Light Burner—Vertical Section, page 824.

mixing chamber, B. The lower end, C, of the manifold distributor, D, fits over B. The mixture of air and gas, ascending through the lower part of the distributor, passes through the cylindrical gauze, E, into the three arms leading to the burner nozzles, F, only two of which are shown in the figure. The gauze serves the usual dual function of forming a more perfect mixture and of preventing back firing. G is one of three openings, each opposite a mantle and supplying a jet of flame found necessary to insure satisfactory ignition. A shade holder, H, may be incorporated as part of the burner base, and is shown in dotted outline.

Mantle

The "C.E-Z" mantle is one of the great factors contributing to the commercial success of the light. It has a "closed top," which hitherto it was possible to use only on pressure lamps. Its dimensions in use are about $\frac{7}{8}$-inch long and $\frac{5}{8}$-inch in diameter, but before being "burned off" the mantle is about twice as long. It is what is known as a rag mantle, and possesses the very desirable property, not true of the other mantles previously described, of immunity from injury by handling before burning off. It has all the support advantages inherent to the inverted mantle, and, in addition, is free from troubles incident to the use of chimneys. Because of its small size, it is inexpensive to replace. The total horizontal candlepower from the three mantles is about 80, with an hourly gas consumption of 3 cubic feet.

Glassware

As already mentioned, one of the advantages of the "C.E-Z" light is that its small size permits its use and concealment within the dimensions of globes commonly found on old type fixtures, and its low first cost and high illuminating efficiency makes such use very widespread. For complete installations, modern fixtures and globes of attractive designs are available. Figure 258 shows a modern globe partly broken away to give a view of the burner and mantles.

Pilot Light

Figure 257 shows the recently invented "fabric" tip pilot light. K is a metal tubing (clay is used for an inverted burner) forming the jet outlet. The mantle fabric is formed into a roll about this jet tube, and when gas is delivered to it and lighted, the fabric burns away, leaving a hardened but porous ash, like the fabric of a mantle. Gas courses through the pilot

tube and escapes through this porous roll of mantle ash. When the gas is lighted, it burns at the surface of the ash, producing a glow, but no visible flame. The pilot will remain lighted even in considerable wind and the gas consumption can be as low as

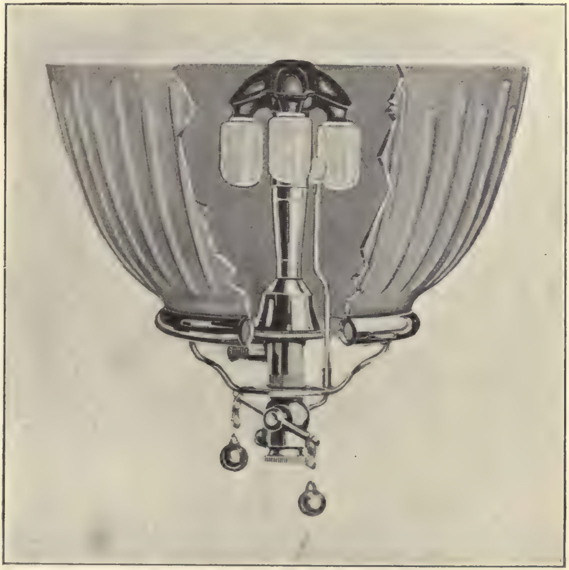


Figure 258.—C. E-Z Incandescent Gas Light, page 826.

one-twentieth of a cubic foot per hour. The gas supply to J is provided from below the cock, L, through an opening in the cock body, and is thus independent of the position of L. It can be regulated or entirely shut off by the screw, M.

A pilot light is a great convenience wherever there is much intermittent use of a light, and it is a necessity where the light is not of easy access, as is true of the arc types yet to be described. Pilots of suitable design are available for every incandescent

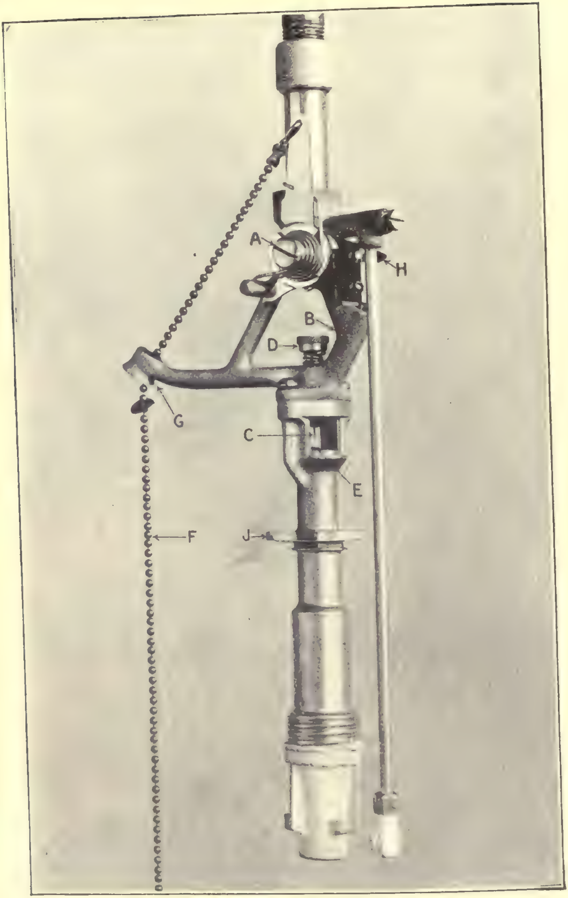


Figure 259.—Single-Mantle Arc Lamp Burner, page 829.

light, but for the sake of simplicity have not been shown in the illustrations, as in the case of the small units the pilot is essentially an accessory and not an integral part.

Large Units

Single-Mantle Arc Lamp

Burner

The lights under consideration so far have been those whose main field of usefulness is in dwellings, rather than stores or factories. When the incandescent mantle brought a new lease of life to illumination by gas, one of the fields rapidly being occupied by electricity was the lighting of large spaces. As the first electric lamps used for this purpose were called "arcs," it was thought good business to apply the same name to the competing incandescent gas burners. Figure 259 and 260 show two views of a single-mantle arc lamp. The burner proper consists of the same elements as the inverted light previously described, though throughout it is sturdier and of larger dimensions. Because of this similarity it is not thought necessary to describe it in detail or show a vertical section, and only its peculiar features will be described.

In Figure 259, the gas supply comes down the overhead pipe and passing through the cock, A, enters the bent arm, B. A screw tapped into the elbow of this arm allows easy access to the lower portion. At the bottom of the arm the needle valve is located. Its point is shown at C. The position of the needle in the gas orifice, and therefore the extent of gas flow, is regulated by turning the screw head, D. The needle valve is readily removable for cleaning by the entire withdrawal of the screw. For convenience of regulation, the present type has a wire handle projecting beyond the stack, S, Figure 260, and this handle moves screw D by engaging with its slotted head.

The primary air ports, E, are shown full open, but they may be partly closed by the forward rotation of the brass thimble, whose edge may be seen in the right of the opening, E.

Figure 260 shows that the main gas cock is above the lamp. It is conveniently controlled from below by the pull chain, F, Figure 259, attached through the handle, G, to a ratchet mechanism. With the cock shut, one pull opens and the next pull closes. The position at any time is known from below by observation of an indicator arrow, one of whose ends, H, in the shut-off position is shown in Figure 259. The cock is also out of

Figure 260.—Single-Mantle Arc Lamp, page 829.

the path of the hot combustion products. These are diverted to opposite sides of the stack by a metal partition, shaped like the inverted frustrum of a pyramid, the top (lower surface) of which is at the level of the projections, J, and whose outward flaring sides extend upward surrounding the air ports, E, and end in the plane of the stack top. This partition thus, besides serving to keep the gas cock cool and therefore in good working order, also keeps the combustion products from entering the air ports. Furthermore, the dispersion and the outward direction from the center given to the escaping products greatly decreases any discoloration of piping or ceiling.

The stack, S, Figure 260, is finished in white enamel and is about $6\frac{1}{2}$ inches long and $5\frac{1}{2}$ inches in diameter. Its primary function is to obtain the increased draft required to furnish the secondary air needed for the large mantle.

Mantle

The mantle used is similar to that described for the inverted light, but is larger, its length being $2\frac{1}{2}$ inches and its diameter $1\frac{3}{4}$ inches. The ability to obtain sufficient illumination from one mantle, and the resultant simplicity and low maintenance cost of the lamp, is the novelty of this single mantle arc, and makes it very desirable for all situations adopted to its illumination range. Its horizontal candlepower is 200, with an hourly gas consumption of 9 cubic feet.

Glassware

The inner cylinder is 6 inches long and 3 inches in diameter. Outer shades are available in materials and shapes sufficient to meet every need.

Three-Burner Indoor Arc Lamp

Burner

The lighting requirements of many interior spaces exceed the possibilities of the single-mantle arc. To obtain the necessary increase in light, a number of mantles are grouped in one lamp, and it was this use of mantles in multiple that characterized the first arc lamp. Three mantles have proved to be the most satisfactory number for indoor arcs, and the particular type selected for description has no superior in this field. Figure 261 is a vertical section. Gas passes from the pipe, A, through the passage, B, into the hollow plug, C. Openings, D, in this communicate with the arm, E, containing the gas cock, F. From the cock the gas passes into the plug, G, through openings, H.

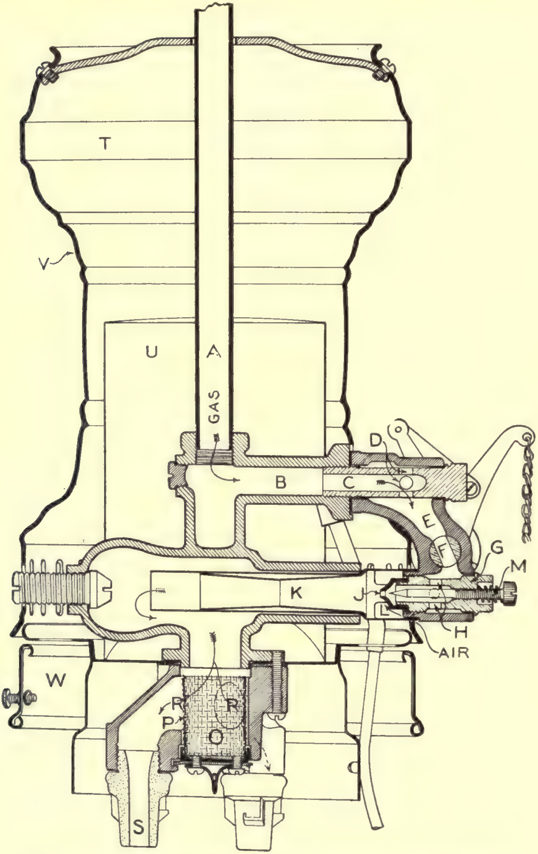


Figure 261.—Three-Burner Indoor Arc Lamp—Vertical Section, page 831.

From here the orifice, J, leads to the mixing chamber, K, where the gas mixes with the air entering through fixed orifices, L. The gas flow is regulated by the needle valve, M. The gas and air mixture passing out of K, turns downward and enters the chamber, O. This has as an inner lining the removable cylindrical gauze, P, through which the mixture must pass through openings, R, into three passages, each leading to a burner tip, S.

The three castings, containing the gas and air passages, are readily separated or removed, and at all important points removable plugs afford ease of inspection. The castings with their parts are located in a vertical chamber, extending across the stack and occupying the central segment of its circular section. The outer space on each side is filled with a metal vent, which conveys the hot products of combustion to the stack top, T, and keeps them from undesirable contact with any working parts. The inner vertical plane face, U, of one vent is shown behind the vertical section.

The stack casing, V, is usually finished with white enamel, ornamented with horizontal gilt stripes, as shown in Figure 262. To this casing is fastened the nickel-plated globe band, W, Figure 261, also seen in Figure 262. The latter figure shows the vertical slots for the admission of secondary air through the bottom of the casing. On the left is seen the pull chain which operates the gas cock through a ratchet mechanism—one pull on, one pull off. The on and off positions are clearly indicated by the indicator arrow there shown in the off position.

Mantle

The mantles used in this lamp are the same size as those in the inverted light. Its horizontal candlepower is 330, with an hourly gas consumption of 12 cubic feet.

Glassware

Figure 262 shows a globe whose upper hemisphere is largely of diffusing glass. Probably the globe of most frequent use is one with an alabaster finish. Its inner surface is of opal glass and its outer is of clear glass. It sends out a very soft diffused light.

Five-Burner Outdoor Arc Lamp

Burner

The lamps hitherto considered have been for indoor use. In the outdoor lamp, dependability of operation is of the utmost importance. Such a lamp is often the only lighting unit employed, and its outage is, therefore, a more serious matter than

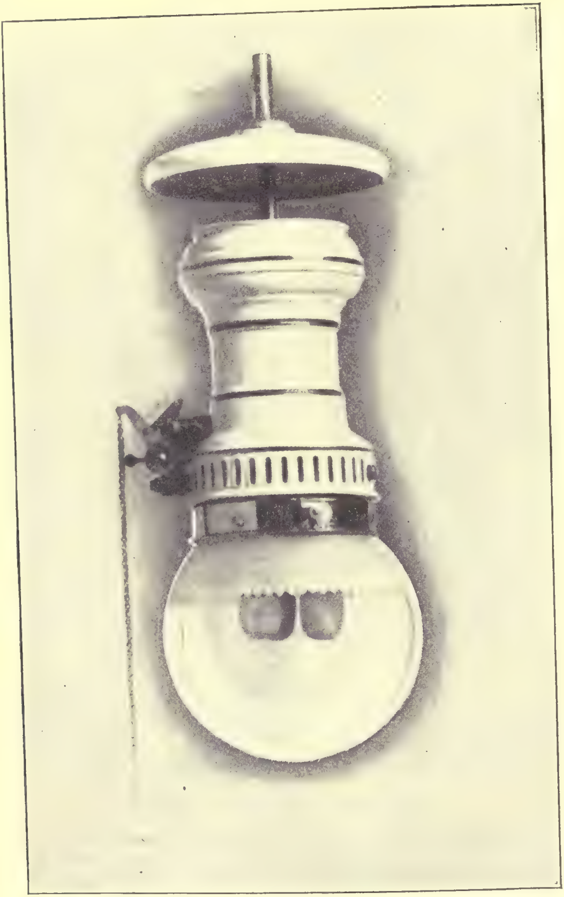


Figure 262.—Three-Burner Indoor Arc Lamp, page 833.

that of an indoor light, usually forming one of several lights available for the same enclosure. We will now describe a type of outdoor arc lamp whose parts are so proportioned and related as to make it practically proof against serious disturbance from wind, rain or snow storms, and which, therefore, has had many years of successful use under these trying conditions inseparable from exposure to the weather. Its design also provides ease of access and simplicity of inspection or attention for those parts whose proper functioning is necessary to a standard volume of uninterrupted light. This is the more important because of the awkward locations in which these lamps are often placed.

Figures 263 and 264 are vertical sections, the former showing the complete lamp, and the latter the detail of the gas supply to one mantle. (A magnifying glass may be used to advantage in studying Figure 263.) The gas coming from the piping system must pass into the drip cup before it enters the feed pipe. This cup performs a very important function, intercepting condensation that otherwise would pass down the feed pipe and create trouble. The removal of any condensation is effected through the opening shown in the lower left-hand corner.

Below the drip cup is a ball and socket joint, which takes up any impact or wind pressure strains transmitted from the lamp. These, in the absence of a flexible connection, might often result in broken piping.

The gas, entering under the umbrella-like head of the tube projecting into the drip cup, passes down through the ball and socket joint and the by-pass cock, and enters the main feed pipe. At its base, A, Figure 264, there are five openings, each leading to a burner tip. The five burners are mounted in a circle upon radial arms, B, running from the feed pipe. At the end of each arm is a separate bunsen base, C, carrying the orifice and the gas adjusting needle. This needle projects above a ledge of the outer shell or case, D, and is, therefore, very easy of access for adjustment or removal.

From the bunsen base, a removable bunsen tube, E, extends obliquely downward to the deck plate, F, and sockets in a casting, G, which projects through the deck plate and provides a threaded end for the attachment of the burner tip, H. In the tube, E, may be seen a thermostat, J, in its closed position.

Primary air enters through three fixed orifices, K. This, as well as the secondary air, is supplied to all the burners from a common reservoir embracing all of the central portion of the

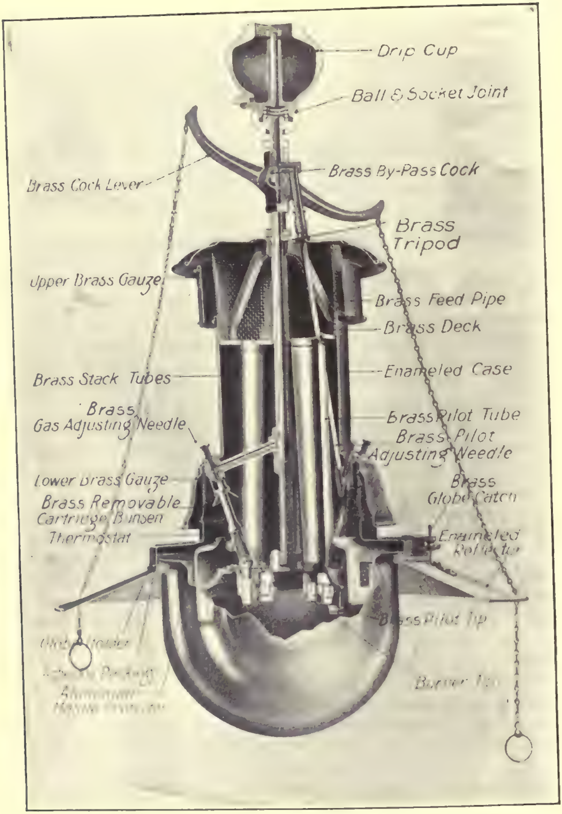


Figure 263.—Five-Burner Outdoor Arc Lamp—Vertical Section, page 835.

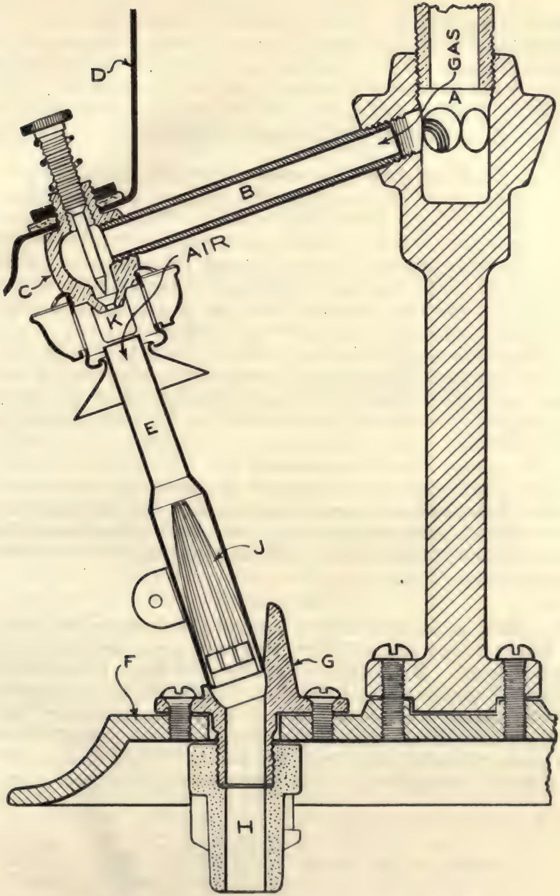


Figure 264.—Five-Burner Outdoor Arc Lamp—Details of Burner, page 835.

lamp not occupied by the stack tubes. The provision of sucn a common and relatively large air supply chamber is exceedingly important for successful functioning in wind. Figure 263 shows the air chamber extending as far up as the "brass deck." Outer air enters beneath and within the entire circumference of the "overskirt" casing, passing through the ring of "lower brass gauze."

The same figure shows the stack tubes, one centered between each burner tip. They convey the products of combustion to the space at the upper part of the lamp. This is surrounded by brass gauze and further protected by a weather band from direct attack of wind or rain. Passing through the gauze, the products emerge from under the umbrella-like top of the housing structure.

The pilot light is wind-proof, and the by-pass cock is conveniently operated from the ground by a pull chain.

In this lamp appearance has to be somewhat subordinated to necessary volume of light and dependability of operation. The length from the bottom of the globe to the top of the housing structure is 24 inches and the diameter of the enameled reflector is 20 inches.

Mantles

The mantles used in this lamp are the same size as those in the inverted light, but are more strongly made to be adequate for the more difficult conditions of outdoor use. The lower hemispherical candlepower is 515, with an hourly gas consumption of 18 cubic feet.

Glassware

The globe is an 11-inch bowl, readily removable for cleaning, but which can be cleaned fairly well in place as supported by the reflector band. By reason of its size, the heat it receives from the lighted mantles is not sufficient to raise its temperature to a point rendering it liable to fracture from drops of water. When the globe is lowered, a metal skirt drops down around the burners and protects the mantles from the wind. Either clear or diffusing glass is obtainable, but the latter is ordinarily preferred.

CHAPTER LXXIV

CONNECTION PRACTICE

Location of Appliance

General Principles

When the first representative of the distribution department arrives on the premises, whether a preinspector or a fitter, he should interview the consumer and decide on the exact location of the appliance. The "box" system, explained in Chapter LXIII, is seldom used in the connection of illuminating appliances, for the reason that none of the work lends itself as satisfactorily to that method as do some portions of fuel appliance work.

When the location is not determined by the existence of an outlet or of a fixture, but, on the contrary, the desired installation involves running piping and placing outlets or fixtures at definite points or for definite purposes, care and thought must be used in deciding on the best location. In large installations, or even on smaller ones of importance, an illuminating expert has previously made plans for all the details (see Figure 186, page 628), and so the fitter, or the preinspector, is guided by a sketch showing the various locations of units and sometimes of the piping itself (see Figure 187). In small installations, the experience of the representative, combined with the wishes of the consumer, suffice for the determination of a satisfactory location. In any case the decision is made in accordance with the following principles. In listing them, no attempt is made to touch on the questions of distribution or intensity of illumination.

> The contact of combustion products with inflammable material above the lamp is the most common fire hazard to be avoided. In a horizontal plane the danger is from draperies or window curtains. A mantle light having glass shades and chimneys, if used over easily burning goods, involves a slight risk

from the falling of mantle pieces while still incandescent. This can be eliminated by the substitution of other materials for glass. The careless dressing of a show window might involve a hazard in any direction.

Lamps should be kept far enough from the sprinkler heads of fire extinguishing systems to eliminate the possibility of melting the head control.

When installing a lamp on a fixture, be sure that the latter is of sufficient strength to withstand the strains imposed by the added weight and the frequent pull on any pilot by-pass chains. Weakness is frequently evident in swing brackets.

Avoid accident hazard incident to lamps or fixtures hung too low in a passageway or projecting from a wall in any undesirable location.

Usually, greater care on the score of sightliness than is necessary in the case of fuel appliance connections, should be used in determining the location of any piping for illuminating appliances. Such piping often must be exposed to view on the side wall or ceiling, and the choice of location may considerably affect the degree of satisfaction with the installation.

The preceding considerations not interfering, the location needing the smallest amount of connection labor and material should be chosen.

Exposure

The various types of lamps are carefully designed with reference to their expected exposure to draughts and weather extremes. For this reason it is seldom advisable to use any type under conditions for which it was not intended. However, although an indoor lamp never should be placed outside, yet an outdoor lamp sometimes may be used inside. Locations for indoor lamps should be chosen, so far as possible, to avoid draughts which may blow out the pilot flame.

Sufficiency of Supply

Service and Meter

The usual illuminating appliance installation adds such a relatively small consumption to the existing demand that no change in service size nor, especially in dwellings, in meter size

is required. Large installations, often involving new piping and additional outlets, require the procedure for service and meter described in Chapter LXIII.

Piping

When the proposed installation involves only the connection of a single fixture or appliance to an existing outlet, it is unnecessary to consider the question of the size of the line supplying that outlet, because if the system of piping has been installed in accordance with the rules in Chapter LIII, the size of that line will be sufficient for the requirements of any ordinary fixture or single or multi-mantle lamp. When the installation involves the connection of more than one fixture or lamp, or the extending of pipe from the outlet, careful consideration should be given to the conditions affecting the supply available for the proposed additional load. The size and length of such an extension, the advisability of using more than one outlet for the purpose of supply, and the necessity of providing a booster line from some other section of the existing system, are features which enter into this problem. When the installation involves a complete system of piping, it should be made in accordance with the rules in Chapter LIII.

Connection

Shutting Off Gas

Before starting the connection work, gas must be shut off at the nearest control cock, except when the piping involved is $\frac{3}{8}$-inch or less, and when the making up of not more than two or three threads is involved. Even in such cases, gas must be shut off if there is involved any hazard to person or property. The precautions to be observed if gas need not be shut off are given in Chapter XLIX.

General Requirements

At this point it is best to insert the rules which, in a general way, govern the features that always apply to installation and sometimes to maintenance work.

> Before starting an installation, be sure that the gas pressure at the outlet nozzle is sufficient.
>
> Every lamp should be controlled by a cock conveniently near and always in sight of the lamp.
>
> Use jointing material as follows: Iron to iron or brass to iron, usual pipe jointing; brass to brass, none

if threads can be made up tight, otherwise brown soap or grease.

If a burner screws too loosely on the fixture nozzle, use washers to fill space between burner and shoulder of nozzle.

If a canopy or box back is part of the installation, make it fit snugly against the wall or ceiling, using a spacing piece if necessary.

In every case it is assumed that a by-pass (a cock with pilot connection) is to be installed. In general, no specific mention is made of just when to install globe or shade ring. It is assumed that this is self-evident.

After adjusting pilot, and before putting mantles in place, blow out the pilot flame.

Direct pilot flame so that it will not touch glassware.

When installing glassware, use extreme care to prevent it from touching mantle.

Leave by-pass or cock chains so that they are within easy reach of a person of ordinary height.

When, because of peculiar conditions, the heights that may be suggested or advised in the discussion of certain types of appliance are not applicable, the question must be determined in accordance with general conditions.

It is not advisable for the workman to remove an electric arc lamp, if this will interfere with the proposed work, unless special permission has been obtained from his foreman, who should give this permission only after he is thoroughly conversant with the conditions of electric supply and knows that no hazard will be created. If the workman removes the lamp, he should receive special instructions about the treatment of the electric wiring that he has disconnected. Difference in practice involving "series" or "parallel" wiring make this an important feature.

When an electric fixture (as distinguished from an electric arc) has been disconnected, and the wiring from the outlet is not to be used again, the ends should be carefully taped and left separated.

When a combination gas and electric fixture has been removed, before it is rehung, the gas outlet pipe through wall or ceiling should be covered as far as the

insulating joint with fibre insulating material at least $\frac{1}{32}$-inch thick. When a fitting, such as a tee or cross, has been installed on the gas outlet above the insulating joint to provide for a branch gas line, the branch line should be covered with this insulating material from the fitting to a point $\frac{1}{4}$-inch outside the canopy.

To make a joint in electric wiring, twist wires at least four times, solder, wrap with approved insulating material, and then cover with friction tape.

Adjustments

A lamp may be said to be best adjusted when, for the longest time without readjustment or mantle renewal, it gives the proper amount of light. Before endeavoring to adjust any lamp, be sure that pipes, cocks, orifices, gauzes, and other gas passages are clear and clean.

A lamp with upright mantle should be adjusted, after installing and burning off the mantle, by turning the gas adjusting screw to the point where the mantle shows the maximum brilliancy, at the same time avoiding the cone of flame that may appear at top of mantle. This cone may be most easily seen by placing the hand between the eye and the lamp, the upper edge of hand being on the line between eye and top of chimney.

A lamp with an inverted mantle, or mantles, depends for its satisfactory service on the proper adjustment of the flame within the mantle. When a mantle is in position, the flame within it cannot be seen, and as the mantle brilliancy is not an indication of proper adjustment, there can be no certainty of an adjustment made with the mantle in place. In other words, the most brilliant mantle is very often wrongly adjusted. The knot at the bottom of an inverted mantle will appear dark with any adjustment, and no attempt should be made to make it white. The only proper method is to adjust the bunsen flame to the desired point before installing, or after removing, the mantle. It is possible to so remove any inverted mantle except the "C. E-Z". This adjustment on an ordinary inverted burner should be made as follows: When the gas pressure is between 2 inches and 3.5 inches, open air shutter wide; if higher than 3.5 inches, close it the amount that experience shows necessary. Regulate gas adjusting screw until the inner green cone of flame is sharp, strong, and of the length specified in the instructions for installing the various types of lamp. Then install the mantle and the glassware.

If the bunsen flame has been adjusted as explained above, there will be no necessity of making any adjustment after the mantle has been installed.

After making sure that pilot adjusting screw, rod and tip are clean and clear, regulate pilot flame of a lamp used indoor to a length of $\frac{5}{16}$-inch (excepting "Junior" light), and of a lamp used outdoor to $\frac{3}{8}$-inch or slightly longer.

Mantles

Mantles are of two types, the first, where the mantle is burned off in the factory, and then is coated with collodion to prevent damage in shipment; and the second, which is shipped as made, known as the "rag" type. The collodion-coated mantle should be removed from its carrier and installed on the light in such a manner as to prevent absolutely, before burning off, any contact with box, fingers or other object. The slightest touch will damage it and shorten its service. There are certain "tricks" in removing mantles from their carriers which minimize this danger, and these should be familiar to every workman.

Before installing, adjust burner as explained under "Adjustments." Remove the collodion coated mantle from the carrier in the position corresponding to that after installation and keep in that position until installed. Hold an inverted mantle by one of the nibs on the ring, and an upright mantle by the metal base. Rag mantles are not injured by handling before burning off.

Ignite the upright mantle at top, and the inverted mantle at bottom, holding mantle box below latter to catch any excess coating that may drop.

Gas should not be turned on during this process, and the glow in the mantle fabric should be allowed to disappear entirely before turning gas on. After a rag mantle has been installed it should be allowed to burn for 15 minutes, to harden the fabric where it is tied to the mantle ring. This is a very important requirement. It is not necessary to allow the collodion coated mantle to burn after installation, because it has been hardened during manufacture; however, burning 1 or 2 minutes will prove beneficial.

Upright Light

The clearance between the ceiling and the chimney top of the burner should be not less than 24 inches, unless a mica canopy or some other approved protection is used, in which case it may be not less than 15 inches.

Make installations as follows: Screw burner to by-pass. Screw this combination to fixture. Place burner and pilot rod in position. Put on mantle and burn off. Adjust pilot flame. Put on chimney. Light mantle with gas adjustment open full. Adjust to greatest brilliancy, avoiding the cone of flame that may appear at top of chimney. This cone is most easily seen by placing the hand between eyes and lamp, upper edge of hand being on the line between eye and top of chimney. Put on glassware.

Inverted Light

The clearance between the ceiling and the globe ring of the burner should be at least 18 inches, unless a metal shield, 8 inches in diameter, is placed directly above the by-pass, in which case the clearance may be not less than 9 inches.

Screw burner to by-pass and place pilot rod in position. Screw this combination to fixture nozzle or gooseneck. Open air shutter full. Turn on gas and adjust to a sharp green cone about $1\frac{1}{4}$ inches long. Adjust pilot flame. Shut gas off at both by-pass and fixture key. Put on mantle. Turn on fixture key. Burn mantle off. Turn on by-pass key and light mantle. Put on glassware.

Junior Light

Make installation as follows: Screw burner to by-pass, inserting globe ring between the two when the glassware requires it. Now proceed as explained under "Upright Light." In general, the top of the chimney should be not less than $\frac{1}{4}$-inch below top of globe. If secondary air supply is insufficient, use intensifier (short extension of chimney).

C.E-Z Light

Make installation as follows: Screw burner to by-pass. Screw this combination to fixture. Open air shutter full. Turn on gas and adjust to a sharp green cone about $\frac{3}{4}$ inch long—never less. Adjust pilot flame. Turn off gas at fixture cock. Take off burner head and screw on mantles. If the diameter of the globe ring is less than $4\frac{1}{2}$ inches, which will indicate the use of smaller than standard glassware, and will cause consequent proximity of mantles to glass, slip the protecting gauze into place. Replace burner head. Burn off mantles without turning on gas, and wait until the glow in the mantle fabric has entirely disappeared. Put on glassware, turn gas on full, and instruct consumer to allow

light to burn for 15 minutes to harden mantles. This is very important.

Domes

The height of a dome above a dining-room table should be such that an imaginary line between the lower edge of the dome shade and the eye of a person seated at the table will pass just below the mantle of the lamp. If the table is rectangular or oblong, the person should be assumed to be sitting at the middle of the long side. If the dome is not used to light a table in the dining-room, the height may be decided on in accordance with the rules for the height of fixtures.

The dome should be installed as follows: If necessary, the pipe drop to which the stem is to be hung should be shortened to permit the canopy to rest snugly against the ceiling. Then the stem should be screwed to the outlet and made plumb, the spider fastened to dome, and the whole screwed on the stem. Then the lamp should be installed.

Fixtures

In residences, the following clearances between floor and lowest part of fixture—or lamp, if this projects below fixture—are desirable.

	Over Table	Not Over Table
Hallway	.....	7′ 0″
Rooms	5′ 10″	6′ 3″

In stores or factories, the fixtures used for general illumination, and hung above a passageway, should afford a clearance of not less than 6 feet 6 inches, and preferably a clearance of 7 feet for upright and 7 feet 6 inches for inverted lamps.

The height of lamps hung to light special operations, machines, etc., should be determined by the conditions governing the individual case.

The least permissible clearance between the ceiling and the top of an open-flame burner is 24 inches, unless a smoke bell or other protecting shield is used, in which case the minimum distance is 18 inches.

The position of a lamp intended to light the operation of a cooking appliance should be to one side of the appliance, so that the products of combustion and the vapor from cooking will not interfere with the cleanliness and efficiency of the lamp.

Fixtures and brackets should be handled with care to avoid tarnishing, and, with the exception of those of iron pipe or cast

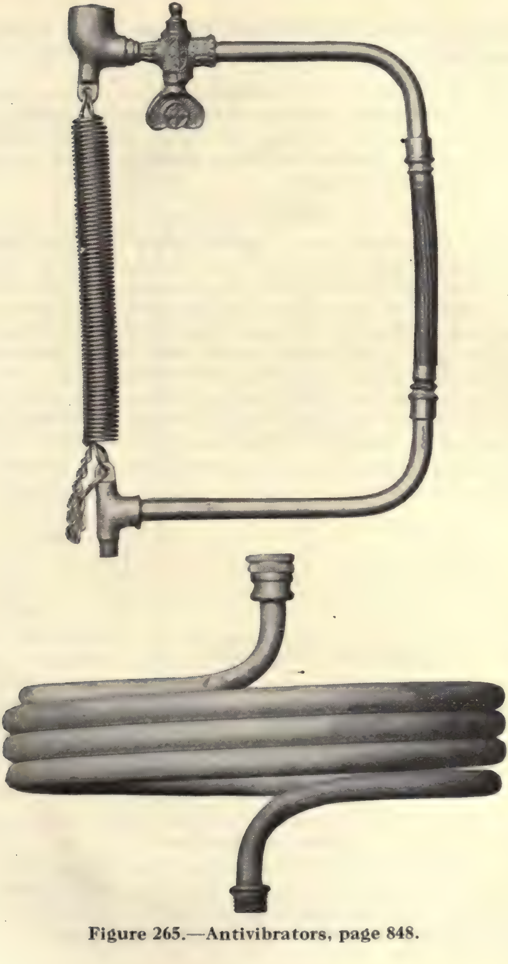


Figure 265.—Antivibrators, page 848.

brass, should not be touched with the bare hands, clean gloves or cloths being used during the operations of installing.

Antivibrators

When a lamp will be subjected to the vibration caused perhaps by machinery or by moving objects on the floor above, an antivibrator, two types of which are shown in Figure 265, should be installed above the lamp.

Indoor Arc Lamps

Most of the details to be observed when installing indoor arc lamps have already been given in the preceding general instructions. The ceiling fire hazard sometimes entails the use of an 8-inch baffle plate or a 16-inch ceiling shield to deflect the hot products of combustion. For an inverted arc, the ceiling shield should be used in preference to the baffle plate, and it always should be used when the distance between the top of the stack and the ceiling is less than 6 feet. A space of at least 4 inches should be left between the shield and ceiling. The best position for the shield is from 12 to 18 inches above the top of the stack.

The following heights are recommended, the figures shown being the distance between floor and lowest part of lamp.

Type	Height
Upright	8′ 0″ to 9′ 0″
Inverted, 3-burner	8′ 0″ " 9′ 0″
" 4- "	8′ 6″ " 9′ 6″
" 5- "	9′ 0″ " 12′ 0″

After the lamp has been hung on the connections, the gas should be turned on and the piping and appliance carefully examined for any leak. After this has been found satisfactory, or made so, the gas flow should be adjusted (for inverted lamps with mantles of ordinary size) to a bunsen flame with a sharp green cone about $1\frac{1}{2}$ inches long. Then the pilot flame should be adjusted, the mantles installed and burned off, the globe placed, and the consumer instructed in the proper methods of operation.

Outdoor Arc Lamps

Figure 266 shows the most simple type of outdoor arc connection. The supply is obtained from an inside outlet, perhaps in the front room or bulk window, and the piping is extended through the outside wall; in this case, through the window frame.

The outdoor piping is enlarged to prevent freezing; this enlargement being made, whenever possible, inside the wall. The ell placed at the upper end of the vertical run, just above the lamp, is tapped on its top and a $\frac{1}{8}$-inch brass plug inserted. If frost

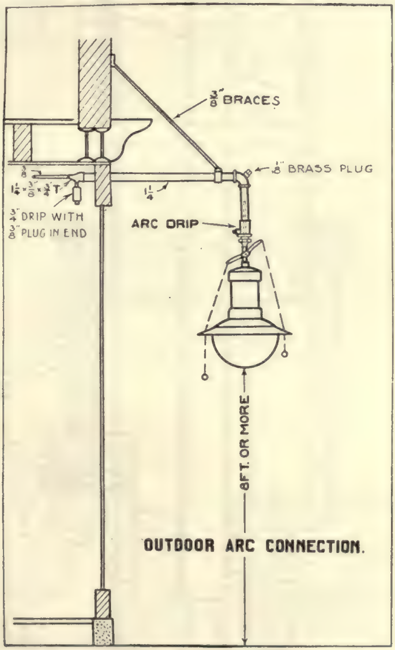


Figure 266—Outdoor Arc Lamp Connection, page 848.

accumulates at that point, alcohol may be injected and the liquid drained off through the set screw of the drip, which is always placed just above the lamp. The details of this drip are shown in Figure 267.

Figure 268 shows the type of connection used when the point of exit of the pipe through the building wall is not sufficiently

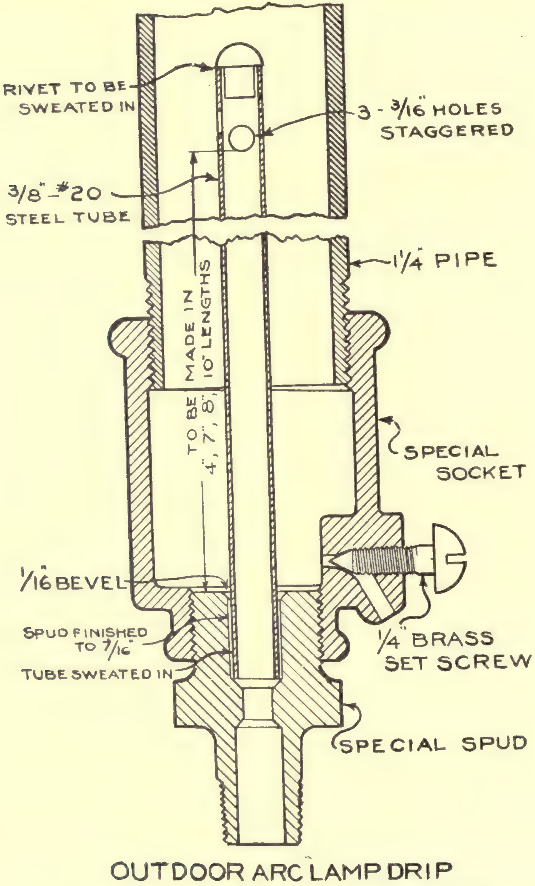


Figure 267—Outdoor Arc Lamp Drip, page 849.

high to give head room to the lamp if installed as in Figure 266. In this case 45° ells are used as shown, the lower one being tapped and plugged.

The method of ignition ordinarily used with an outdoor arc lamp is the pilot flame, the main cock being operated by pull chains. This method sometimes is inconvenient to the con-

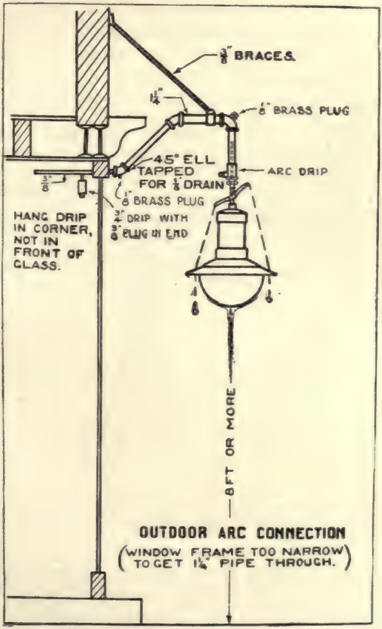


Figure 268.—Outdoor Arc Lamp Connection, page 849.

sumer, especially in inclement weather; also, there exists the chance that the lamp may be lighted or extinguished by unauthorized or mischievous persons. To overcome these difficulties, the connections are installed as shown in Figure 269. Here the

main supply cock is placed at some convenient point inside the building, and the pilot flame is supplied through a separate line, taken from a branch outlet on the meter side of the main cock. This pilot line is of $\frac{3}{8}$-inch pipe and is installed for some distance within the main $1\frac{1}{4}$-inch feed pipe, to make the installation more sightly. Figure 269 shows also the method used to enable the automatic extinguishing of the lamp at some predetermined time. This is used principally in connection with show-window lighting when the store is closed, but where it is desired that the lamp will burn until the time when the number of evening passers-by is not worth attracting. To do this, the main supply

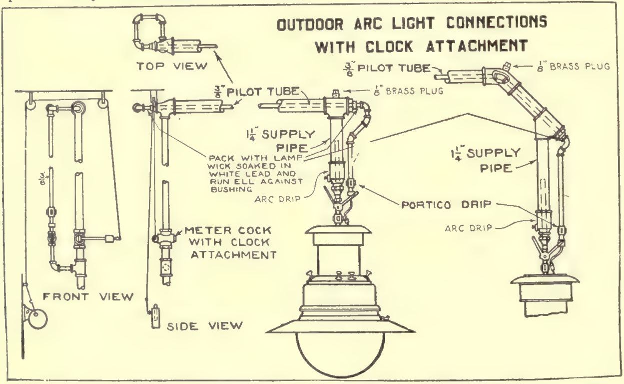


Figure 269.—Outdoor Arc Lamp Connection—Inside Supply Cock, page 851.

cock is equipped with a lever handle, so weighted that it will close if released. This handle is connected to the "alarm wind" stem of an ordinary alarm clock, in such a manner that when the alarm starts and the stem revolves, the weight is released and the lamp extinguished.

The outdoor piping shown in Figures 266 and 268 is $1\frac{1}{4}$-inch, because this size presents the best appearance with lamps containing three or more mantles of the ordinary type. There are other lamps with fewer or with smaller mantles, for which smaller piping is more suitable. In such cases the same principles of connection should be applied, but the piping may be 1-inch or sometimes $\frac{3}{4}$-inch.

The following principles apply generally to the installation of all outdoor lamps.

> The height of an outdoor lamp should be not less than 8 feet.
>
> The outdoor piping should not be graded toward an indoor fixture without providing a drip to prevent condensation running into the fixture. When all outdoor piping cannot be drained into the drip above the lamp, and if it is not desirable to install a sufficiently large drip inside, an additional one may be placed in the line just outside the wall. However, an inside drip is desirable under all conditions.
>
> If the reducing fitting is outside of the last point of support of the horizontal line, or if the horizontal distance between the lamp and this last point of support is greater than three feet, the pipe braces should be used, otherwise they are not absolutely necessary.
>
> These braces should be fastened to the building, and not to any structure subjected to vibration, such as an awning frame.
>
> The connections should be given a priming coat of red lead, and a finishing coat of some dark color, preferably black.
>
> Lamps hung at a great height should be equipped with rings, at least two inches in diameter, on the end of the pull chains, for ease of engagement with the hook of the lighting stick.
>
> The most common fire hazard is that imposed by movable canvas awnings. In this case a distance of 20 inches between top of stack of lamp and canvas is advisable. If less, a shield should be used.

After the lamp has been hung on the connections, the gas should be turned on and the piping and appliance carefully examined for any leak. After this has been found satisfactory, or made so, the gas flow should be adjusted (for inverted lamps with mantles of ordinary size) to a bunsen flame with a sharp green cone about 1½ inches long. Then the pilot flame should be adjusted, the mantles installed and burned off, the globe placed, and the consumer instructed in the proper methods of operation.

Each of the several types of lamp posts specially designed for the use of outdoor gas arc lamps requires that the lamps be

attached to the post in accordance with the design. The post should be installed as explained in Chapter XLIII.

Inspection

After the installation has been completed, the workman should carefully inspect each section of the installation and should correct any faults found.

Instruction

After everything is satisfactory, the workman should request the consumer to examine the installation to be sure it is in accordance with his wishes, and that the appliances, especially the glassware and mantles, are in good condition. Then the consumer should be instructed in the details of operation. According to the type of burner or lamp, some or all of the following principles will apply:

> The by-pass chains should be pulled all the way down.
>
> The lamp should never be turned low.
>
> If the pilot goes out, it should not be relighted through holes in glassware, but always from above.
>
> Consumer should understand how to adjust pilot flame.
>
> The glassware should be kept clean, and the consumer should understand how to remove it from lamp and replace it.
>
> If lamp cock is equipped with an indicator to show its position, the consumer should understand its use.

Other Work

The making of records and the cleaning up of dirt should be made by the workman in the same manner as explained in Chapter LXIII.

Subinspection

Since the fitter who makes the installation of any illuminating appliance must be competent to make the final adjustment, it seldom is necessary to make a subinspection visit for such adjustment, unless for some reason it is thought wise to check up within a day or so the adjustment of a type of lamp which sometimes gives trouble in the beginning, or when, for any other reason, perhaps in the case of a large installation, or a new user of gas illumination, or both, it is likely that such a visit will serve a useful purpose.

Sufficient inspections of every man's work are advisable, to insure a high standard in the quality of work and in the instruction of the consumer. The seemingly minor features involved in an illuminating appliance installation are relatively much more effective in creating a good or bad impression on the consumer than are those involved with a fuel appliance.

CHAPTER LXXV

MAINTENANCE ROUTINE

Methods Employed

It is apparent from the two preceding chapters how much attention has been paid to the design and installation of illuminating appliances. The result desired is furnishing to the user the appliance best adapted to his needs and so installed as to give the maximum of efficiency with the minimum of maintenance care. Chapter LXI discussed, in a general way, "request" and "free" maintenance as applied to both fuel and illuminating appliances. In this chapter the reference is to illuminating appliances exclusively.

The *average* gas consumer has not sufficient inclination and, even if supplied with illustrated instruction charts containing clear and detailed directions, does not possess the knowledge to give proper attention to his lights, especially if they are of the multi-mantle type. Cleaning glassware may be considered as the extent of his care. Therefore, to retain for gas anything like its proper proportion of the lighting field, the gas company must furnish a maintenance service. The simplest and cheapest method is to make visits only in response to the consumer's request for attention. As the reduced efficiency of a light is apparent to the eye, it might be supposed that lighting troubles would be reported more promptly than defects in fuel appliances. This does not seem to be the case. At least with such "request" maintenance there are innumerable cases of unsatisfactory lights of which no complaints are ever made, even though there would be no charge for such attention. One explanation of this unfortunate failure of the consumer to notify the company of bad lighting conditions has been given in the second paragraph of Chapter LIII.

A second method is a combination of "request" and "periodic" maintenance, the latter at ten-day intervals, the consumer paying a fixed monthly amount for the service. These con-

sumers are usually users of gas in stores and factories. A third method involves free periodic maintenance by visits three or four times yearly to all consumers not willing to pay for the more frequent service given under the second method. Although a considerable revenue is made from material sold to the consumer, this all-embracing maintenance service is apt to involve a large expense. It does, however, result in greatly increased lighting efficiency and must be credited with an unknown but probably large increase in gas consumption by the retention of gas lighting in places where, in the absence of the maintenance service, another illuminant would be substituted.

A maintenance man, besides having a thorough knowledge of all lighting units, should be experienced in the finding and remedying of all troubles incident to services, meters and piping.

Adjustment and Repairs

Even with satisfactory conditions of gas supply and a lamp properly adjusted on installation, the gradual changes that often alter these original conditions very considerably are: Changes in the gas pressure due to piping, fixtures or cocks becoming obstructed; deposits of dust or other particles within the lamp mechanism and on the glassware; unavoidable wear and deterioration of the lamp parts. In general, while a temporary improvement in a condition resulting from any or all of these causes may often be effected by merely adjusting the gas and air mixture, yet it is the duty of the maintenance man to remove the first cause of the trouble, and this cause may be deep seated and remote from the lamp itself.

Deposits of carbon on mantles, burners, and glassware is one of the most common causes of complaint, because they greatly diminish the amount of light and present a very unsightly appearance. The one cause at the bottom of every carbon trouble is the fact that the mixture at the burner tip contains too much gas or too little air. This condition may result, first, from an improper adjustment of the gas and air regulators; second, from gas pressure insufficient to draw the necessary air into the mixing tube; and third, from various local conditions of dirt and wear in the lamp mechanism.

The remedy for improper adjustment is easy when it concerns only a regulation of the air or gas, and this should be done as explained when discussing installation. It often is possible by a change in adjustment to remove a carbon deposit from a

mantle, but this remedy is never permanent when the trouble is due either to the second or third condition previously mentioned, and should not be applied until the absence of these conditions has been proved.

If necessary to remove such a deposit, proceed as follows: Close the gas adjusting screw until the mantle becomes dim, open air shutter wide, and allow mantle to burn until the carbon has disappeared. Never try to burn off carbon by partly turning off fixture key. This will reduce pressure at lamp orifice and will increase the carbon.

The second condition—lack of pressure—is the one which affects all lamps alike. If a carbon deposit appears at several points in the building, it is reasonably certain that low pressure is the cause. When suspicion is thus directed to the system of supply, investigation should be made for stoppage in piping, for wrongly adjusted house governor, for meter defective or too small, and for obstructed service. The details of such investigations are covered in Chapter LVII. If this investigation does not prove conclusively that the pressure is poor, a careful measurement of pressure should be made with all the appliances in use. The existence of less than 2 inches water column at any point is proof that low pressure is the cause of the trouble. The relation of the pressure measurements will indicate the location of the cause, and the remedy should be applied as previously explained.

When the carbon deposit is confined to one lamp only, or if to several lamps widely separated, the cause usually will be found to be local. When due to dirt or dust in the lamp mechanism, it may be necessary to take the lamp apart to remove it, or perhaps only to clear out the orifice and gauzes with an air blower, which is a specially designed hand bulb with a long thin nozzle. When the cause is worn or burned out lamp parts, they should be removed. When the cause is the consumer turning light low, or of attempting to adjust the lamp himself, he should be warned against this practice.

Other local causes of, and remedies for, the "carboning" of mantles are as follows, listed under the various types of lamp to which they are peculiar.

UPRIGHT LIGHT

1. *Cause:* Dust or dirt in bunsen tube and on gauze.
   Remedy: Clean out.

2. *Cause:* Lack of or too small holes in chimney.
Remedy: Remove deck plate if any. In the "Junior" light ventilate globe ring or use intensifier (extension of chimney).
3. *Cause:* Stoppage in fixture or by-pass cock.
Remedy: Remove stoppage.

INVERTED LIGHT

1. *Cause:* Wrong adjustment.
Remedy: Re-adjust, first removing mantle.
2. *Cause:* Air shutter too far closed.
Remedy: Open shutter full and if lamp roars, increase size of distributor.
3. *Cause:* Flash-back, burning thermostat fingers together.
Remedy: Renew thermostat.
4. *Cause:* Distributor misplaced.
Remedy: Replace distributor.
5. *Cause:* Dust in mixing chamber, on distributor and thermostat.
Remedy: Clean out.
6. *Cause:* Bunsen base defective.
Remedy: Renew base.
7. *Cause:* Dust on gauze in top of bunsen base.
Remedy: Renew gauze.
8. *Cause:* Stoppage in by-pass or fixture key or swing joints, due to grease; or at either end of fixture, due to jointing material.
Remedy: Remove stoppage.

ARC LAMP

1. See No. 1 under "Inverted Light."
2. *Cause:* Flash-back, coating gauzes with carbon, and gauzes dirty from other causes.
Remedy: Clean gauzes.
3. *Cause:* Adjusting screw bent,—gas shot toward side of raceway.
Remedy: Renew screw.
4. *Cause:* Orifice reamed or stretched by closing adjusting screw with unnecessary force.
Remedy: Renew orifice.

The most common cause of pilot outages is a stoppage at the adjusting screw. This stoppage may be due to moisture or scale,

or to invisible particles which are deposited by the gas. The workman should bear in mind the fact that in most cases he never will be able to see the cause of the stoppage, and should make sure that all gasways through which gas passes on its way to the pilot tip, are clean, clear, and dry. The pilot tip and rod should be in good condition. He should make sure that no cock grease or jointing material is, or can be, deposited on the adjusting screw or its seat, and should clean and dry these parts thoroughly. Pilot outages may easily be caused by pressure fluctuations due to obstructions in service, meter, or supply piping.

The troubles previously mentioned include all those most frequently encountered in illuminating appliance maintenance. Local troubles may be due to some feature in lamp design which is peculiar to that make of lamp and which therefore is not treated here. The proper method of installing mantles has been touched on in Chapter LXXIV, as have also the general details of how to secure proper burner adjustment. Replacement of glassware should be made with the care indicated when discussing its installation.

PART X

THE STOREROOM

Under this heading will be described the organization and operation of a storeroom. A stock of materials is essential to the work of a distribution department and such a stock involves many details of accounting and of physical care. These details are fully brought out in the following pages, the aim of which has been to show forth the fundamental principles of storeroom operation and the benefits to be derived from a proper organization in such a way that each reader could apply the information to his own particular situation.

SECTION I

ORGANIZATION

CHAPTER LXXVI

ACCOUNTS

"Storeroom" Account

There are probably some gas engineers, and also accountants, who do not believe that the practice of charging material, when bought, to "Storeroom" and when used, to the proper account, is worth the bookkeeping involved. They charge their cast iron as bought to, say, "main extension," crediting to this account and charging to an operating account what little cast-iron material may be used on repair work. Their pipe and other material for service work are treated the same way, being all charged to "new services," and a credit given for material used on renewing existing services. The material for inside work is all charged to, say, "distribution supplies" account. The above is not intended as an exact description of such a system, but merely as a general outline of its features.

As a result of this method, what is saved as compared with the maintenance of a "Storeroom" account? None of the expenses incidental to the physical care of the material, or to the record of the amount on hand, but only the relatively insignificant clerical labor of charging up against various accounts the material used. It is true that the sheets containing the information for charging out the material must be made out by the employees using the material, or inspecting the finished work, but experience has shown that the amount of other work accomplished is not appreciably lessened thereby.

On the other hand, what is lost by not keeping a "Storeroom" account? First, an exact knowledge of the material cost of the various classes of work done. When material is charged out as

bought, the only way to obtain some idea of the material cost of any particular job, such as setting a meter, or connecting a gas appliance, is to keep a record of the material actually used on several hundred jobs, and get therefrom an average cost. By repeating this process at intervals, a figure will be obtained for each class of work, which, multiplied by the number of jobs, will give the total material cost for this work for the period covered by the jobs used as a multiplier. Again, there are classes of work, such as main and service laying, where the material used follows as a matter of course from the length of main or the length and number of services. Right here, however, it may be said that the expense of charging out service or main material is much less than for a corresponding value of material used on fitting jobs, so that while the need of a "Storeroom" account to distribute correctly material costs is least in the case of main and service work, the expense entailed by charging out this material is also least.

From what has just been said, it follows that if the "Storeroom" account only enabled the correct charging of material, this information might be sufficiently well obtained by a cheaper method. A "Storeroom" account has, however, a second and more valuable advantage in that it shows on the books at all times the amount of money invested in unused material. Any undue accumulation of material swells the storeroom figure, and this accumulation cannot progress far, unless there is gross neglect on the part of the management, without being noticed and an explanation demanded. The book value of storeroom stock replaces for the manager of a large company, the intimate acquaintance of his stock possessed by the superintendent of the small company, who is in and out of his storeroom and storeyard every day. The larger the company, the harder it is for the manager, or superintendent, to see all his stock, the easier undue accumulation takes place, and the greater the necessity for the "Storeroom" account. The use of the latter as a regulator of material will now be discussed.

Let us consider, as typical of a large company, that there is a general manager, an engineer of distribution, a superintendent of stores, and several district superintendents with their storekeepers. The general manager should, from the best information at his command, preferably by asking the opinion of subordinate officials, determine upon a figure beyond which the stock must not be allowed to go until the matter is brought to his

attention with a reason for the increase and his consent obtained. This figure will naturally increase with the growth of the company, and, therefore, should be expressed in terms of that growth. A very simple, and, at the same time, quite accurate way is to limit the stock to a definite amount per consumer supplied, or, what is generally the same thing, per meter in service. Possibly in a year when there is a great amount of new construction, or in a company which does a large and varying business in piping houses and selling fixtures and incandescent burner supplies, it may be found advisable to consider certain classes of material, the required stocks of which depend upon the sales being made, in terms of these sales, but these will be exceptional cases. Also, as it is usually necessary to accumulate material for seasonable work, the figure settled on by the general manager should refer to the stock as carried at the beginning and ending of each season, and more or less discretion should be allowed the storekeeper, or whoever is responsible for keeping up stock, as to the amount of the accumulation, it being clearly understood, however, that an explanation must be forthcoming if any errors in judgment result in an excess stock at the year end.

What the figure should be for each plant, will be settled by local conditions, and be greatly affected by the nearness to sources of supply and promptness of freight delivery, and by the character of the curve representing the monthly requirements of material throughout the year. There will probably be reasons to change it from time to time, but once settled, it saves the manager from the time-wasting practice of scrutinizing each requisition for material, and by thus removing one source of frequent delay in the prompt placing of orders, has a tendency to decrease the amount of stock necessary.

The engineer of distribution, if he has the right kind of a superintendent of stores, will not be justified in seeing every order for material, but should have personal knowledge of the large orders for such material, the demand for which will depend upon new construction, such as cast-iron pipe and specials and steel pipe, or be affected by impending changes in the policy of the company, such as brass cocks for service or stove lines.

The methods employed by the superintendent of stores to prevent overstocking and at the same time run small risk of running out, will be described when telling of the operation of the storeroom.

A system as above outlined renders entirely unnecessary a useless and time-consuming, though often perfunctory, initialling of material requisitions by a lot of officials, and yet it absolutely limits the accumulation of material. Such a system, coupled with proper rewards for those men who show their ability to furnish prompt service to the customer and yet maintain a low material stock, will produce results obtainable in no other way.

"Expense Storeroom" Account

When no "Storeroom" account is maintained, the cost of caring for and issuing materials must be classified as well as may be, presumably to the same accounts and in the same proportions as is the material itself. When, however, there is a "Storeroom" account, as there should be except in the smaller situations, the opening of "Expense Storeroom" enables a very accurate apportionment of the cost of handling material.

To this account should be charged every expense not directly caused by specific material, such as rent, office supplies, inventorying, and handling and hauling mixed loads. The expense of handling large shipments of one article should be charged to "Storeroom," being added to the price of the article, as also rent, tools, labor, material, etc., incidental to making pipe coating, coating pipe, assembling fixtures, etc.

If the storeroom is often called upon to do special work and to care for material not carried in "Storeroom" account, it is obvious that the expense of handling, together with the amount of necessary supervision and space occupied, should be charged to the proper accounts and not to "Expense Storeroom." The volume of these special duties may be great in a large city, especially where the stores division cares for a carpenter shop, an appliance laboratory, the storage of old records, the transfer of miscellaneous items from one office to another, the sale of material to other plants and the issuing of orders and approving bills for items not charged to "Storeroom." These should be as few as possible, being limited to automobiles, motor cycles, large machinery and all large and expensive material not actually handled by the storeroom force.

If in any large situation care is not taken, as indicated above, to separate correctly the costs that belong to specific material from those that apply equally to all classes of material and, therefore, are properly chargeable to "Expense Storeroom," the tendency will be to overload the latter account, show an erro-

neous cost of handling material and unjustly penalize the accounts using this material.

In the years prior to the present new business activities of gas companies, the accurate segregation of items properly chargeable to "Expense Storeroom" from other expenses, as above described, was all that was requisite, even in the largest situations, to obtain the correct cost of handling material. In those days the materials in a distribution department storeroom were fairly homogenous; therefore, each dollar's worth of one class cost as much as a dollar's worth of another class, and it was entirely proper to apportion each month the "Expense Storeroom" charges against the accounts using "Storeroom" material in the direct ratio of such use. As soon, however, as a company enters the merchandising field, and places in stock and sells to its consumers many varieties of fuel and illuminating appliances, the storeroom situation is radically changed. "Storeroom" now includes, besides the former distribution material required to carry out franchise obligations, a heterogeneous assortment of what may be termed new business articles, placed in stock in order that by their sale not only shall output be increased, but also a merchandising profit result. This being the case, the cost of handling the new business material is essential for correct profit or loss merchandising data. Experience indicates that, as compared with distribution material, the handling cost of new business articles is always a greater per cent of the issue value. In the case of illuminating appliances and accessories, and of especial fragile material, such as domes, fixtures, mantles and glassware, there are items of insurance, supervision, indoor storage space, inspection upon receipt and issue, and careful packing, that do not apply at all to cast-iron material, or only in a very small degree. Therefore, a continuance of former methods of apportioning "Expense Storeroom" will result in a lower than true cost of handling this merchandising material, and unduly increase the cost of straight distribution work, the result being, on the one hand, a fictitious merchandising profit, and on the other, inflated extension or repair costs.

A further reason in a large situation for a subdivision of "Expense Storeroom" between various classes of materials, is that such subdivision tends to economy of operation by showing clearly the amount of work done each day by the different elements of the storeroom force. The following subdivision has been used:

Incandescent material.
Cocks, fittings, steel pipe, etc.
Fuel appliance repair parts.
Cast-iron pipe and special castings.

In order to arrive at the proper classification of the daily labor, it is very essential that the order men and helpers record the various divisions of their daily work, and at the close of each day report to their foreman the total time properly subdivided. Except in the case of a specific activity, such as a carpenter shop, the classification of the executive and clerical force is more difficult, but a fair approximation may be made.

There will be certain charges to "Expense Storeroom," such as office and shop supplies, rental of space used for general storeroom purposes, cleaning, loading and handling miscellaneous lots of material, and general supervision, which are in the nature of general expense charges and must be pro-rated between the subdivisions of "Expense Storeroom" in the ratio of productive labor charged against each subdivision.

By following the system above outlined, the proper data will be obtained each month for charging out "Expense Storeroom" against the various issues, with percentages varying according to classes of material.

CHAPTER LXXVII

ORGANIZATION

Main Storeroom

In Chapter II will be found the argument for a superintendent of stores as the head of the storeroom or stores division. In a city of over 200,000 meters, an assistant superintendent is also justified.

The superintendent is responsible for the operation of his division, and, subject to general rules of policy and limiting figures for the stocks of various classes of material, should be given a free hand and then judged by the results attained in lowering handling costs, in decreasing the ratio of stocks to issues, and in perfecting an efficient storeroom force.

At the main storeroom, in addition to an assistant superintendent or chief clerk, there should be a storekeeper, assistant storekeeper, head bookkeeper, head stenographer, inspector, receiving and shipping clerk, stationery clerk, senior and junior clerks, order men and helpers.

The storekeeper should see that all material is properly cared for and correctly accounted for when used. He should be in direct charge of the following:

Supervision of the storeroom and yard, appliance repair and machine shops, tinsmith, carpenter, janitor and watchman.

Taking inventories.

Loading and unloading wagons.

Routing delivery wagons.

Determining material to be ordered by requisition.

Shipping, receiving and receipting for material.

Inspecting the counting of material and personally signing the shipping receipt.

He should give especial attention to:

Ordering supplies of all kinds.

Economical handling and checking material as received.

Issuing material to the workmen.

Quantity carried in stock and by workmen.
Accounting for material used.

The head bookkeeper should supervise:

Recording of material received and issued.
Making monthly reports of journal entries to the comptroller's office.
Compilation of stock ledger balances by classes of material.
Districting charges.
Preparing insurance data.
Passing invoices and freight bills.
Checking lists of inactive material.

Where this work is not done directly under the eye of the assistant superintendent or chief clerk, the head bookkeeper should be held responsible for the discipline of and results obtained from the clerks under him.

The head stenographer should have charge of all stenographic work, filing, ordering material not regularly carried in stock, and dispatching reports, statements, inventories, etc., on schedule time.

The superintendent of stores should keep in close touch with the district organization by personally visiting each storeroom from time to time, and, in addition, should have the assistance of an inspector, whose duty it should be to inspect the work in the district storerooms to see that instructions are being followed, and that all material is being properly accounted for. He should be thoroughly conversant with the entire storeroom practice, and be competent to recommend changes in practice.

The inspector should report the result of his investigation to the district superintendent, or his chief clerk, and make a detailed report to the superintendent of stores of any feature of interest to the latter.

The bookkeeper should keep a composite record, by districts, of all material expensive or marketable, and, therefore, likely to be stolen. He should notify the superintendent of stores whenever the records indicate that there is too great a discrepancy between the actual and the recorded stock. He also keeps a complete record of the important tools, whether in the district storeroom or on the street.

The stationery clerk should be responsible for ordering, receiving, inspecting, storing and shipping forms and stationery.

In addition to the above, sufficient senior and junior clerks should be employed to take care of routine work.

Order men and helpers are under the supervision of the storekeepers, and are regularly employed in receiving and checking the receipt of material, preparing material on orders, etc. The order man, by reason of his knowledge of material location in the storeroom and his proper observance of low stock condition, is exceptionally valuable to the organization, and should be encouraged with good wages and the chance of promotion.

District Storerooms

In addition to the main storeroom, a district storeroom will be needed at every district shop. The employees required may be: Storekeeper, assistant storekeeper, storeroom clerk, and helper. The volume of work will determine the necessity for an assistant storekeeper, or clerk, and the number of helpers needed. The duties of the storekeeper are similar to those of the same position at the main storeroom.

CHAPTER LXXVIII

SIZE AND SITE

Size

In determining the size of storeroom facilities, if conditions as between two companies are assumed to be comparable, the required square feet in floor and yard space should be in proportion to the value of the maximum stock on hand or possibly to the number of meters in service, but a great deal depends upon the size and kind of material to be stored. Some Philadelphia data on this subject is as follows:

Value of stock	$300,000
Number of meters	420,000
Indoor space at main storeroom . . .	60,000 sq. ft.
Outdoor " " " "	45,000 " "

In any situation the division of the material into classes and the determination of the area required for each class will be of assistance. Such classes are stationery and tools; street main materials; steel pipe; fittings, cocks, etc.; fuel appliances and parts, and illuminating appliances and parts. Besides this active material, space will be needed for the storage of old records, scrap material, excess stock purchased in advance because of price, derricks and other large tools and possibly construction department outfits, an appliance laboratory, a carpenter shop and material for sale to outside plants. Sufficient space must be provided for ample receiving and shipping facilities, such as adequate platforms adjacent to a railway siding and to a roadway, to be used as free space for both loading and unloading. Also, space should be provided for mechanical devices used to expedite the movement of material.

The floor area required will vary according to the headroom available on each floor, to the floor carrying capacity, and to the size and character of appliances or material to be carried in stock. For example, when storing gas ranges (crated or knocked down) in a building with floors 12 feet high, with a floor carrying

capacity of 100 pounds to the square foot, the single-oven type of range may be piled four high; the double-oven type, three high; the cabinet type, two to four high, and the special cabinet cannot be piled at all, although the latter class may be conveniently stored under platforms or racks. The storekeeper should make a careful survey of the space available and allot it according to the size and weight of the materials to be stored.

In general, more space in proportion to the issues made will be needed when the area of operations require a main storeroom and one or more district storerooms. A very important factor in its influence on area is what proportion of any of the fuel appliances sold by the company is made locally, and therefore may be delivered directly from the factory to the consumer. Such local deliveries are possible in every city making good fuel appliances, and result in great economy as compared with the expense of handling appliances from out of town.

SITE

Considerations of real estate owned by the company often determine the location of the storeroom, especially when there is but one, and in that case it is generally found at the gas works. The larger the situation, the more does final economy require that each storeroom be so located that operating costs are a minimum.

The main storeroom should, if large enough to require many carload shipments, have its own siding from one or more railroads, or its dock if water transportation plays an important part, or perhaps both facilities.

Any district storeroom should be located at the distribution shop. At times a suitable shop location is too restricted in area to accommodate more than the shop and storeroom, so that the storeyard and the stable must be located elsewhere. Before such a separation is decided on, careful figuring should be done, as it will be often found that two sites increase the cost of operation far more than would be casually supposed. This is especially true where the stable (or garage) is removed from the shop, owing to the cost of transportation over this unproductive distance.

A storeyard isolated from the shop will usually contain only street main materials and large tools. Often holder stations are available for the former, but here again transportation costs are apt to govern and make the cheapest location that nearest the stable.

All storeroom buildings should have adequate ventilation, heat, light, elevator capacity, and covered loading and unloading facilities, with sufficient roadway approach to afford quick ingress and egress to all transportation equipment.

SECTION II

OPERATION

CHAPTER LXXIX

ORDERING

Relations with Purchasing Department

As a purchasing department affords the most efficient means of obtaining the best material at the lowest price, its permission should be obtained before an order is placed directly with a dealer. The purchasing department should accept verbal or written orders from only those employees authorized to make such requisitions. This rule will not only prevent unauthorized persons from obtaining material in the company's name, but will also avoid the difficulty of tracing the origin of an order which had not been numbered in the storeroom series.

Specified classes of articles, such as rubber stamps, hardware, housefurnishing materials, lumber (up to a limited value) and similar material may with advantage be purchased without first sending each order through the purchasing department, if the latter has previously consented to this plan and possibly furnished a list of dealers from whom purchases should be made.

When it is desired to write a dealer regarding a credit, replacement, cancellation, or other reasons, the letter should go via the purchasing department, mentioning order number, or should it be necessary to write directly to the dealer, the purchasing department should receive a copy.

In hurrying forward material due on order, it is advisable to do so through the purchasing department, which, having placed the order and arranged details as to price and time of delivery, is in close personal touch with the dealer and will probably obtain better results.

Ordering Routine

When to Order

As a gas company uses hundreds of articles of which it is essential that a working supply be kept constantly available at the storeroom, or at the makers ready for delivery, it is of supreme importance that the responsibility for ordering material be placed with competent men supervised by others higher in authority.

Over- and under-ordering may be guarded against, and when to order, readily determined by the adoption of a minimum stock record. This minimizes the chance of exhausted stock,—a costly and, from a storeroom standpoint, unpardonable occurrence. All bin cards, Figure 270, should show the minimum quantity of material to be carried in stock for the respective bins. When the stock has reached its minimum, the order man should refer to his stock record cards, Figure 271, take out the cards for such material, mark thereon the stock on hand and the date, and turn the cards over to the storekeeper, who should in turn consult the ledger for the quantity used, taking into consideration the probable activity of each item, and place an order to replenish the stock. The stock record is then returned to the order man with a notation as to how much was ordered, and this record serves as a notice to the order man of material due on order, and is checked off when the material is received.

Valuable as is the minimum stock record in general, it need not be followed in the above detail for large stocks of material ordered at stated periods of the year, such as cast-iron pipe and special castings, steel pipe, nipples, brass cocks, fittings, etc.

Cast-iron pipe and specials should be ordered by the distribution head, because, except for certain bends and branches, past use is no sure index of future requirements, and of these latter, he is in the best position to know. In a large company, the pipe is usually bought by yearly contract with specified deliveries each month. Two weeks' supply should always be in stock to care for emergency needs or delay by railroad or foundry.

In Chapter XII under "Stock of Specials," the use of an inventory form was mentioned. Such a form enables the distribution head to order all the specials needed in Philadelphia by devoting less than an hour's time, at quarterly intervals during the year, and results in an adequate supply without an unduly large stock. A specimen page is shown in Figure 272.

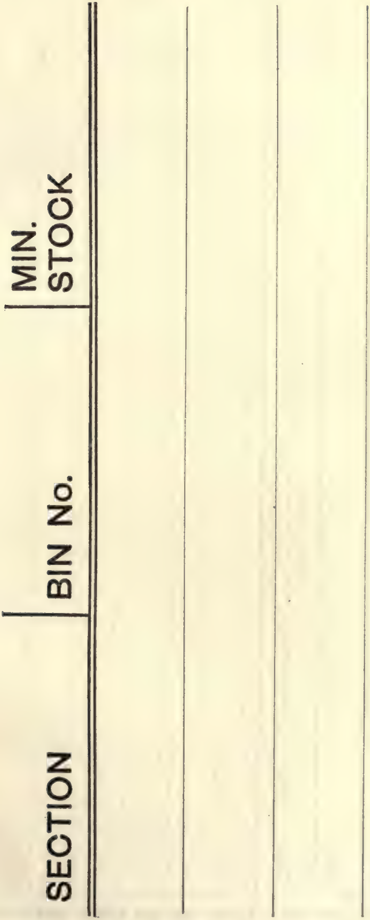

MIN. STOCK
BIN No.
SECTION

Figure 270.—Bin Card, page 876.
(Actual size, 3" x 5")

STOCK RECORD

SECTION..................

BIN.

MIN.

Date	Stock	Ordered	RECEIVED		Date	Stock	Ordered	RECEIVED	
			Date	Quantity				Date	Quantity

Figure 271.—Stock Record Card, page 876.
(Actual size, 3″ x 5″)

CAST IRON SPECIALS STOCK REPORT

DATE.....................19.......

MATERIAL	STORE YARDS				TOTAL STOCK	Inventory Jan. 1st.	Received	Total Received	USED	Due on Orders
	A	B	C	D						
BENDS 90°($\frac{1}{4}$)										
3″										
4″										
6″										
ETC										
60° CIRCLE										
3″										
4″										
6″										
ETC.										
45° ($\frac{1}{8}$)										
4″										
6″										
ETC.										
45° ($\frac{1}{8}$)										
4″										
6″										
ETC.										

Figure 272.—Stock Report of Cast-Iron Specials, page 876.
(Actual size, 8½x11—10 pages)

Before ordering steel pipe, cocks, fittings, etc., it is also important to know what amount of material will be required in the year, and, as far as possible, during each month of the year.

At times, the purchasing department decides that to take advantage of low prices, needs should be anticipated for possibly a year, and calls on the storeroom for the requisite orders.

Here, in the main, past requirements must be the guide, and to be equipped with the necessary data, the information called for as below should be prepared after inventory taking each year:

Size	Kind	Inventory 12-31-18	Due on Order	Used 1917	Used 1918	Ordered 1919

The quantity used is filled in by the bookkeeper from the ledger account of issues. Another method of determining the movement of stock is to have a separate history card for each item, showing each monthly issue in a continuing record from year to year. This is exceptionally valuable in showing the curve of materials used in large quantities. The record of issues should be studied before an order is drawn, investigating any appreciable difference in the issues for the different years, with the bearing this may have on the current year.

On the other hand, when business conditions are unfavorable, to avoid all chance of overstocking, it often is wise to order a few months' supply instead of one year.

All material should be specified to come forward as of certain dates, paying special attention to convenience of handling and storage facilities, taking every precaution to insure as low a stock investment as is consistent with efficiency, yet allowing a safe margin for errors in filling orders, and delay in transit. If material has been ordered with due allowance for manufacturing operations, delivery on time is the rule, but occasionally there is delay and only partial deliveries will be made, so that in the case of special material furnished by only one dealer, it is necessary to set a time for delivery much further in advance of actual need than is required for staple material that can be had from more than one dealer.

The storekeeper will have full play for the exercise of all his judgment in deciding on necessary changes in dates of delivery, especially when material is being used up faster than anticipated.

Material such as cement, lumber, oils and sundry items which may be had promptly from local dealers, need not be carried in large quantities, but delivered as required.

The materials so far considered are those entirely within the control of the distribution department and comprised the entire storeroom stock until the advent of the merchandizing operations of recent years. Now the average storeroom contains many fuel and illuminating appliances and their parts. Permanent overstocking and temporary under and overstocking of this new business material is harder to prevent than for distribution ma-

terial, especially if the new business department believes that every type of appliance must be stocked, and has not learned how to conduct the remnant sales by which department stores get rid of odds and ends. Under these conditions, each year is apt to show a larger amount of money invested in a miscellaneous assortment of appliances for which there is no current demand. However, if the rule of a maximum stock figure is enforced, drastic measures for stock reduction will finally bring the cure.

So much for permanent overstocking. The maintenance of appliance stocks in quantities varying with seasonal demands, so that the stock on hand shall always bear a safe proportion to the week's issue, and, at the same time, not involve an excessive carry-over to the next season, is a problem requiring the best thought of both storeroom and new business departments, if, as is often the case, these two agencies are jointly responsible. Staple articles used in large quantities, such as standard lamps and mantles, are subject to the same rules as distribution material, but water heaters and room heaters are examples of special types which, if offered to the public in great variety and ordered in quantities and for deliveries not carefully considered, will result in stocks often half of the yearly sales, a condition that would ruin a purely merchandising business.

A fairly broad experience would indicate that the new business department should decide as early as possible upon the various appliances to be sold each season, of course changing designs as little as may be, and offering no excessive variety of choice, and then after informing the storeroom of any conditions tending to make sales differ from former years, give the latter full authority as to quantities and times of delivery. This places the responsibility where it belongs, and puts into expert hands the maintenance of stock, instead of allowing it to depend on the less accurate judgment and possibly hurried consideration of the new business department.

Whatever the system followed, statements of appliance stock on hand should be furnished the new business department monthly.

How to Order

Where one or more district storerooms are operated in conjunction with a main storeroom, the former should always have in stock a working supply of such material regularly carried by the main storeroom, but not including a complete line of domes, fixtures and large fuel appliances, and this because of space

limitations and storage details. This working stock at the district storeroom decreases the number of requisitions on the main storeroom and enables quicker service to the consumer. Where quick service is required for material not at the district storeroom, the telephone is used and the time of necessary delivery stated.

The requisitions from the district storeroom should be sent in separate series, according to classes of material, as, for instance, forms and stationery; incandescent material and fixtures; appliance parts; steel pipe, fittings, cocks and all other material. By this means, the main storeroom will be enabled to fill the orders more advantageously and economically.

On the arrival of a requisition, the date is stamped, and also after each item not carried in stock by the main storeroom, the words "Order Purchasing Department." After each item calling for material that requires certain specifications should be stamped "Special Order," to guide the order clerk in referring to the special order file, as explained under "Specifications."

The original requisition should then be passed to the order clerk, and after all items of material that are to be ordered through the purchasing department are crossed off the duplicate copy, it should then be forwarded to the order man so that the "open" items may be filled from stock and prepared for delivery to the district. By this means, the duplicate copy of the requisition from the district is used as a work order at the main storeroom, thereby saving the labor of transcribing.

In order that as far as possible the shipping work of the main storeroom should be uniform throughout the week or month, each district storeroom should be assigned definite days on which to order stock material.

The storeroom order on the purchasing agent is made out in duplicate, calling for shipment to be made to the main storeroom or to a district storeroom, according to the kind of material. In the latter case, a copy of the storeroom order should be sent by the main storeroom to the district storeroom, to be held awaiting the receipt of the material.

The long train of evils possible from duplicate orders, such as cancelling one order, request for credit, double payment for one shipment, double delivery, afford ample justification for rigid adherence to the routine laid down to prevent a duplicate order.

Material Specifications

The storeroom should have a file for material of a special nature, in which should be found cards, Figure 273, alphabetically arranged, showing all the specifications to be given when placing an order for any special material such as the following:

Appliances	Fittings
Blocks and wedges	Oils
Boxes, service	Pipe, cast, steel and wrought iron
Castings, special	Posts, lamp
Cement	Vehicles and parts
Clamps, leak	Yarn
Dies and chasers	

These cards should show the size, weight, price, grade, catalog number, blueprint number, shipping directions, name of concern from whom to purchase, and all requisite information that would enable the dealer to promptly furnish correct material without being compelled to inquire for more details or specifications.

When giving specifications for material of a special nature, such as patented articles, etc., specify the name of the concern from whom you are accustomed to receive the goods. In general it is not good practice to specify "Same as last lot," or "Same as usual," unless you add the previous order number or a description that will lead to getting the correct article. If it should be necessary to submit a sample with the order, place the sample if small in a sealed clasp envelope, pinned to the order (avoid clips), stating "as per the attached sample." If the sample be large or bulky, state on the order: "As per sample which we will forward direct to dealer," etc. Then tag the sample and hold pending receipt of copy of purchasing agent's order, after which the sample should be forwarded to the dealer with a shipping memorandum, reference being made to the number of the order to which it refers.

Shipping Instructions

In ordering material, explicit shipping instructions are important, and the following schedule should be observed:

If ordered in town: Specify name and address of consignee.

If ordered out of town:
- Freight. Name company and freight station.
- Express. Give the company's name.
- Parcel Post. State "If within weight."
- Steamship. Specify name of line.

MATERIAL ORDERED RECORD

SECTION______ MIN. STOCK______

BIN______

SPECIFICATION FOR ORDERING______

ORDER NUMBER	DATE OF ORDER	FROM WHOM ORDERED	QUANTITY ORDERED	RECEIVING RECORD									
				DATE	QUANT.	DATE	QUANT.	DATE	QUANT.	DATE	QUANT.	DATE	QUANT.

Figure 273.—Material Ordered Record, page 883.
(Actual size, 5″ x 8″ card)

Shipments should be directed to the freight station nearest the point of delivery. When an order calls for part or whole carload shipment, the order clerk should notify the transportation division that the order has been placed, giving the quantity ordered, time shipment was requested, station to which it should be consigned, where to haul upon arrival, and any other information that would enable the adjustment of hauling schedules accordingly.

CHAPTER LXXX

RECEIVING AND SHIPPING

General

The greatest care should be exercised in obtaining an accurate record of material received. This should include the weight, count and measurement of the material, the character of packing (as barrels, boxes and crates are charged for and must be checked with the invoice), the mode of transportation, the amount of transportation charges, and whether collect or prepaid.

All material received should be immediately turned over to the receiving clerk, as when material in small lots is delivered directly to the person for whom it was ordered, it is not an infrequent occurrence that it is used without having its receipt recorded, and when the invoice is received later on, there is doubt as to the receipt of the material.

In a large situation, receiving and shipping should be done at well separated respective locations, to avoid any confusion of incoming and outgoing material. Outside and inside signs should guide to these locations. The regulations for receiving and dispatching should be well understood by employees and outsiders alike.

Shipping Memorandum

When material is shipped by the main storeroom to district storerooms, or vice versa, whether by team or otherwise, it is accompanied by a shipping memorandum, which is made out in triplicate, two copies being sent with the goods and the third copy retained. The material upon receipt should be checked with the memorandum, the original of which should be signed and returned at once to the storeroom, and the duplicate retained by the district storeroom. The goods, if valuable (such as brass and lead) or few in number, should be weighed or counted.

When checking, if any discrepancy is found, a second count should be made and the storeroom notified at once, before placing the goods in stock.

Provision should be made on the shipping memorandum for a column showing classification, as it is feasible to use it as a notice to the accounting department to charge out the material, as will be explained under "Accounting."

Receipting for Material

When material is received by teams from local dealers and is accompanied by a shipping memorandum, it is receipted for with a rubber stamp, reading as follows: "*Received subject to count, weight and inspection.* (Signed)..." This is done to facilitate getting the team away, but if the dealer insists upon a count in the presence of his driver, and there should be found a variation between the quantity actually received and that called for on the memorandum, the original shipping memorandum is changed accordingly before signature.

After the necessary checking of the received material, its receipt should be posted from the duplicate of the shipping memorandum to a daily blotter or "receiving record," which should contain name of shipper, quantity and nature of material and how packed, and the purchasing agent's order number. Such of this information not already there should also be entered on the copy of the purchasing agent's order, which then is used to approve the bill. One copy of the receiving record should be sent to the inspection division so that inspection may be arranged for before the goods are placed in stock or sent out.

All shipments received via freight should be recorded in chronological order, as many claims arise over lost and mislaid shipments. Enter the name of shipper, date received, how packed, the contents, station from which received, order number, weight and car number, and leave room opposite each item for the freight bill record, showing the date of freight bill, waybill number, amount of bill and classification.

The shipping memorandum is an important factor in checking the receipt of goods, and should be insisted upon wherever possible. In the case of carload shipments containing many sizes of nipples, fittings,etc., it is good practice to make arrangements with the consignor whereby a shipping memorandum showing the number and contents of each barrel or case, will, in addition to a copy of the bill of lading, be made out and forwarded via the purchasing agent. This is especially valuable in locating a definite article in a carload shipment of hundreds of sizes of fittings, nipples, etc.

In receipting for material received at a district storeroom, a copy of the storeroom order may be used. This copy also serves as a notification to the district storeroom that the main storeroom has ordered certain material for delivery to it.

When the material is received, the storekeeper should post the date received, check off quantity or weight, sign his name, and forward the copy to the main storeroom. If the material is thought to be defective, the supposed defect should be stated. If delivery has been refused for any reason, notice of and reason for refusal should be noted. When the order is again placed, the copy should be forwarded to the district in the usual manner.

In case partial delivery only is made of the material listed on the copy of the storeroom order, another form of receipt, showing from whom received, etc., should be sent to the main storeroom, and the copy of the storeroom order, containing a notation that certain items had already been receipted for, should be held awaiting the receipt of the remainder of the material.

As a record for the district storeroom, the serial number of the storeroom order is inserted on the copy of the requisition on which the material was originally ordered.

Broken and Defective Material

In receipting for material received from a transportation company, if there is a shortage, the delivery receipt should not be signed until the agent notes thereon the exact shortage or damage. In most cases, however, it is exceedingly difficult for drivers to notice breakage or damage. Gas ranges are frequently covered with paper under the crating and a very close inspection might not reveal breakage or badly rusted sheet metal. Though breakage of incandescent material is quite common, it is impossible to notice this except when the boxes and casks are badly broken. However, if the breakage has not been recorded on the copy of the delivery receipt before signing for the material, it should be called to the attention of the freight agent, who will send an inspector to investigate. By being able to point out that the material was well packed, and that most likely the damage was due to handling in transit, allowance may be had for much breakage, but claims should not be made for small units, such as cylinders, mantles, etc., packed in sealed cartons, unless the carton itself shows evidence of being damaged.

Material for replacement should be ordered on the regular form, stating that it is needed to replace damage on account of a

certain shipment, giving full particulars as to the car number, etc. In case the goods were shipped f. o. b. destination, claim must be made by the shipper paying the freight. When adjusting breakage on material f. o. b. point of shipment, the claim on the transportation company should include labor and material expended on the replacing shipment.

Returning Material for Credit

When it becomes necessary to return material for credit or replacement, entries should be made on the copy of the purchasing agent's order in red ink for the date of return of each shipment, and in black ink for the date of receipt of each replacement shipment. A letter should be sent to the purchasing agent outlining the reasons for the return of the material, a copy being sent to the bill clerk as his notice to stop payment. This copy, together with all future correspondence on the subject, is forwarded to the receiving and shipping department, where the matter is carefully followed up.

When writing for replacements, an additional copy of the letter should be retained by the receiving and shipping clerk, on which should be noted the date of adjustment, and the letter then forwarded to the purchasing agent as a notice of completion.

Hauling from Railroad Station

As most of the material received in carload lots is hauled by team or truck, it follows that there should be a definite understanding between the transportation division and the storeroom. The storeroom should advise the transportation division of all carloads ordered forward, giving directions as to the disposition of the material when received. Immediately after the material is hauled, the transportation division should forward to the storeroom a report showing the quantity and kind of material, car number and initials, station from which received, and breakage, if any.

The Order Man

At the main storeroom, as explained in Chapter LXXIX, the order man working from the duplicate copy of the district requisition and from copies of telephone orders, assembles material for shipment. He gets these orders from the shipping clerk at certain times during the day, and should give preference to those marked for immediate attention. He should indicate on the order, by certain check marks, whether the material was made ready for shipment, or not furnished because of exhausted stock.

Articles Temporarily Out of Stock

When unable to fill orders for appliances regularly carried in stock, the main storeroom should notify the district storeroom and salesman by telephone (and confirm by letter) that the article is temporarily (or permanently) out of stock, giving the reason and any information as to the probable date of delivery.

An itemized list of all material that cannot be furnished from stock should be kept constantly before the storekeeper and studied from time to time in search of a way out.

Carriers and Trucks

Mechanical devices are essential for the expeditious and careful handling of material. There are numerous kinds of power and hand carriers and trucks, but those described below are of especial value on account of the great amount of time and labor saved by their use.

Cowan Transveyor

This device, Figure 274, will be found indispensable for moving material from place to place in the storeroom, also for saving time when conveying material to be loaded on wagons. It is an elevating truck which is used in conjunction with movable wooden platforms on which a number of boxes or cases may be piled. The platforms may be constructed of 1-inch lumber, 7 inches high over all, 30 inches wide and 44 inches long, with an aperture underneath 6 inches high 'and 20 inches wide, into which the transveyor is pushed.

After the platform has been loaded and the transveyor is pushed beneath it, by lowering the handle, which serves as a lever, the entire load may be elevated to 1⅝ inches from the floor, which clearance is sufficient over rough and uneven floors and down inclines. To release the platform, the operator presses his foot against a pedal on the transveyor, which lowers the platform to the floor ready for delivery or storage. These platforms may be used to good advantage for permanent storage, as the transveyor can be pushed beneath the platform in an instant and the load may be taken away without handling each receptacle. Transveyors of larger capacities are equipped with a hydraulic ram, which enables the operator to raise and lower the load with less effort and no jarring.

The capacity and the number of transveyors required in a storeroom depends on the weight of the loads to be handled and the volume of business, but a type designed to handle a load of

3500 pounds, and a transveyor for each floor of the building, with sufficient platforms, would answer for the average storeroom.

Figure 274.—Cowan Transveyor, page 890.

BARREL TRUCKS

The single-handle barrel truck, Figure 275, has an adjustable steel hook about two feet long, fastened to the upper cross bar of the truck, and is designed for general use, such as handling odd sizes of kegs and barrels. There are many other types of barrel trucks for warehouse handling, but the chief points to observe in making a selection are the size of the nose or tongue and that the

side standards are suitable for the barrels to be handled. Trucks equipped with all iron slats and metal covered side standards are more durable than the uncovered wood construction.

Figure 275.—Single Barrel Truck, page 891.

Box Trucks

This is a low truck, Figure 276, strong and well made for handling large crated appliances, boxes or casks. It is equipped with spurs to prevent material from slipping off, and, therefore, should not be used for any material that might be damaged in

contact with these spurs. It is generally loaded by jacking up the material or by raising it at one end with a barrel truck. The box truck is then inserted underneath and the material may be hauled away with little or no difficulty.

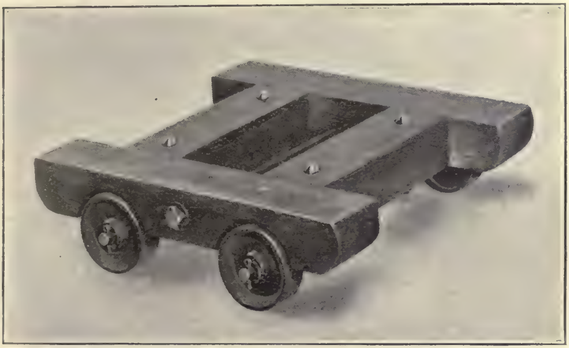


Figure 276.—Box Truck, page 892.

Wagon Truck

This is a popular truck or platform wagon, Figure 277, for storeroom work. It is made in several sizes and is designed for general work in transporting boxes, cartons and casks of uniform dimensions. The most desirable size is one that will pass through the aisles between the bins.

Grocery Truck

This is a platform truck, Figure 278, and may be obtained in several sizes. A 60 by 36-inch platform is especially adapted for unloading a large consignment of cartons of uniform sizes. The truck may be taken inside the railroad car on the siding and then wheeled along the platform into the storeroom with a minimum of physical labor.

Fibre Warehouse Car

This is made of tough material like rawhide and is light and strong. A car of this type, Figure 279, the body of which is 48 inches long, 30 inches wide and 30 inches high, that may be

conveyed through the storeroom, will be found very useful in collecting loose paper and sweepings.

Figure 277.—Wagon Truck, page 893.

Hand Cart

For quickly assembling material on orders specifying a miscellaneous lot of small units, where it is necessary to go from bin to bin and then transport the material to the wrapping table, a two-wheel hand cart will be found very useful and almost indispensable. The cart should be of a size to pass through the aisles and the rectangular body proportioned to the desirable load also.

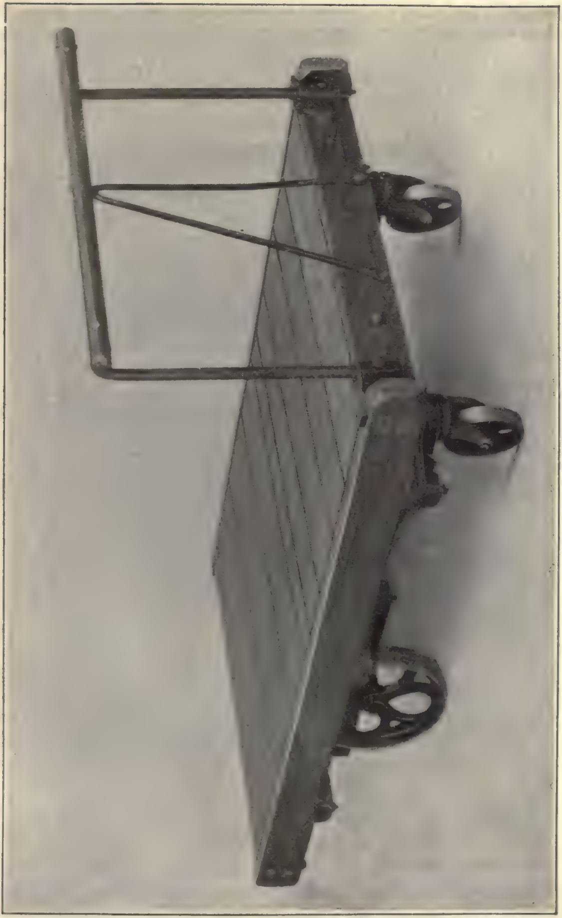


Figure 278.—Grocery Truck, page 893.

An ordinary clothes basket is useful for collecting small units from several different bins.

Scales

The storeroom and storeyard should be equipped with enough scales, of modern design, to do all necessary weighing promptly. Some useful scales are here described.

Wagon Scale

This scale is designed for outdoor weighing and is furnished in a great variety of capacities and platform sizes, but when making a selection, care should be exercised to specify a capacity and size that would answer your requirements as to the character of material to be weighed and both your own and outside parties' transportation equipment. For example, you may have a platform which would accommodate all your vehicles but not large enough for that of a dealer who regularly delivers or takes away large consignments of material.

Dormant Warehouse Platform Scale

This scale is designed for setting directly into any wood, dirt or concrete floor. It is adapted for heavy service, such as weighing barrels of malleable fittings, castings, etc., and its platform being level with the floor, material may be trucked directly thereon. This results, not only in a saving of labor, but of the scale itself.

Portable Platform Scale

This scale is equipped with a floating platform and can be wheeled to any part of the storeroom alongside the material to be weighed. Care should be exercised not to subject it to shock or vibration by placing thereon or taking off extra heavy material. For weighing packages under 100 pounds each, this scale is very efficient.

Parcel Post Scale

This scale is designed to facilitate ascertaining the weight and cost of parcel post packages. It is equipped with both an ounce and a pound balance bar, and the latter has a table on it showing the rate of postage by weight and zone.

Straight Spring Balance Scale

A scale of this type, with a hook for weighing ice or small quantities of material up to 25 pounds, will be found very useful.

Computing Scale

This is a portable platform combination weighing and counting machine. It can do the work of weighing material precisely as

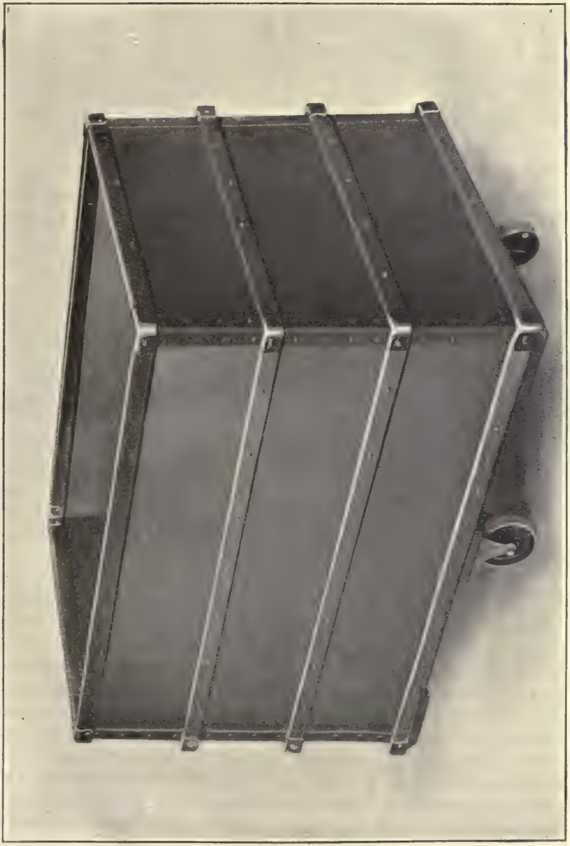


Figure 279.—Fibre Warehouse Truck, page 893.

any standard portable platform scale, and, in addition, it is equipped with computing balance and weight bars, which can be adjusted to furnish the weight and count of small units which must, however, be very uniform in size and shape to obtain satisfactory results. On each of four sides, the computing bar is notched, showing what the total count of any weight should be, based upon whether, two, ten, twenty-five or fifty pieces are placed in a pan suspended from the computing bar. Both the weight and computing bars operate in unison.

Packing and Wrapping Fragile Material

To reduce breakage and damage, great care should be taken in packing fragile material, such as domes, fixtures, glassware, portables and shades. A small article should be wrapped and attached with twine to a large unit so that it will not be overlooked when unpacking. Packing should be used liberally (either hay or excelsior). The compression in a baling press of the packing material taken from incoming cases will provide an ample quantity for shipping purposes and often an excess stock for sale. The press will also serve to reduce fire risks by enabling the baling of waste paper.

Barrels, cases and cartons in which goods are originally delivered, may be utilized occasionally when issuing barrel lots of fittings, arcs and arc globes, box lights, mantles, etc., thereby avoiding extra handling and breakage. In most cases, however, it is advisable to provide special receptacles for the transportation of certain material.

Antifluctuators may be shipped in specially constructed boxes of sizes varying with the antifluctuator, made of 1-inch lumber, with a hole in the center of the lid for the projection of the stem. This stem should be protected by placing two boards at a right angle over its end and fastened to opposite sides of the box. To this arch the stem should be securely fastened, so that the antifluctuator will not touch the bottom of the box, but is suspended by the stem. It has been found necessary to pack antifluctuators in this manner so that during transit the leather diaphragm will not become injured by the unavoidable vibration that ensues. Antifluctuators in storage should be held in the same way.

Domes should be packed in a special case, durably constructed of $\frac{7}{8}$-inch lumber, 30 inches square, and about 36 inches deep, with handles on two sides. A case built of these dimensions will contain three average size domes. In preparing domes for ship-

ment, the packing is placed snugly around and between them, with a bedding at the bottom 6 to 8 inches in depth, and at the top about 4 inches above the crown. No other material should be packed in the same case, excepting the dome rods, which may be placed in a corner of the case well away from the domes, so as to prevent breakage. Mark the lid "*This side up*," to guard against any possible chance of the domes becoming inverted, because if this should happen, the entire weight being on the crowns, breakage would probably result. Dome cases should be carried (not trucked) to the delivery wagon.

Fittings, nipples, stationery and miscellaneous small articles may be conveniently delivered in boxes of uniform size, known as shipping boxes. These are built of 1-inch lumber, 30 inches long, 12 inches wide and 12 inches high, with handles or cross pieces on the ends for ease in handling. For cleanliness, separate boxes, marked on the outside "*For Stationery Only*," should be used solely for conveying stationery.

Fixtures may be shipped in barrels. The arms should be placed in a bed of suitable packing in the bottom of the barrel. Fixtures should not be packed with the stem at the bottom and the arms protruding from the top. This rule appliesto receptacles of all kinds, but especially to barrels, because there is a tendency to utilize a barrel too small for the arms of fixtures, with the result that the arms become broken or strained either in handling or by the shifting of material against them while in transit.

CHAPTER LXXXI

INSPECTION

Introductory

Materials ordered in accordance with certain specifications should have a careful and rigid inspection before acceptance. However, all materials received should be inspected, whether casually or thoroughly, and an inspection division may be found advantageous. A great many miscellaneous items require only a rough inspection to note whether the goods as ordered were actually received, or to pick out broken and defective material, in which case it is necessary to report the conditions on an inspection report, Figure 280, the original being sent to the shipping clerk and a copy to the bill clerk as a check on the approval of the bill, so that either a credit memorandum or a replacement may be obtained. It is very necessary to inspect fittings, cocks, etc., removed from previous connections and reclaimed, before being placed in stock, and also such illuminating appliances as domes, portables, fixtures, etc., before shipment to the consumer. A description of suitable inspection methods for these materials will now be given.

Fittings, Nipples and Steel Pipe

At one period it was probably common practice to buy from one manufacturer all the fittings and pipe used by a company, as this material was not standardized and serious jointing trouble sometimes resulted from the use of several makes. In time, however, the manufacturer either departed from his past standard, or raised his prices, or did both, so that for both reasons the advantages of buying from more than one firm finally outweighed the disadvantages. At first, in changing over, material was specified to be "the same in every respect" as previously bought, but experience showed that definite specifications were needed to obtain articles that would joint with existing stock. In these specifications, the threading requirements are the most important,

STOREROOM MATERIAL INSPECTION REPORT

....191....

QUANTITY	MATERIAL	REPAIR TAG NO.	MFG'S NAME	S. R. ORDER	DATE REC'D	ACCOUNT

RECEIVED FROM

ON ORDER NO..............................FAILED TO PASS INSPECTION

DEFECTS

INSPECTOR.

Figure 280.—Storeroom Material Inspection Report, page 900.
(Actual size, $5\frac{1}{2}'' \times 8\frac{1}{2}''$—loose leaf)

as poorly made threads of varying diameters are the cause of great expense and annoyance if they reach the district shop or the job.

In testing for thread diameter with a Briggs standard gauge, the plug should enter by hand $3\frac{1}{2}$ to $4\frac{1}{2}$ threads, and the ring should engage in the same way on male threads, so that the outer end of pipe or fitting is either flush or not more than $1\frac{1}{2}$ threads of being flush with the outer end of the gauge. When one lot does not quite pass this test, before rejection, samples should be jointed with material that has passed, and if they joint satisfactorily, then the new lot can be accepted.

For inspection purposes, it is generally sufficient to pick out at random only a portion of the entire lot, and carefully inspect for sand holes, rough castings, straightness, splits, condition of weld, burred threads, thickness and diameter of pipe, and gauge of threads. Should this portion show faults to warrant its rejection, the entire lot should be returned for replacement.

Inspection tends to the suggestion of certain improvements. One of these is a recess on the female end of certain fittings extending beyond the first thread, which is thus protected from injury during handling. In this way time is saved, better jointing secured, and threads are protected from corrosion. (See page 375.)

Brass Cocks

A factory inspection of brass service, meter and appliance cocks will amply repay any large company. What was said on page 91, in discussing service cocks, about the advantage of special metal composition and design, applies equally well to meter and appliance cocks. Such factory inspection insures quality of product, and this spells safety as well as economy in distribution work. It has served to educate the manufacturer, who no longer believes that any cock is good enough for gas work, but instead, strives for the best possible product. The inspection cost per cock will be less than three cents.

Two inspections are made. The first starts with a thorough examination of the cock before assembling. This includes a careful inspection of both key and body for uniformity and smoothness of grinding, and for walls, solid and free of foundry defects, and of the key, for freedom from cuts or channels, or light spots due to the springing of the body during machining.

Walls should be calipered and general dimensions taken, carefully noting whether the key has been ground into the body far enough to avoid forming a shoulder at the bottom. Briggs' standard pipe thread gauges should be used to test the tapping. After this has been done, the inspector should place his stamp on the body of the cock, indicating that it has passed first inspection. The cock should then be thoroughly washed, removing all traces of grinding sand from the hex ends, threads, etc. After this operation, it should be subjected to a water test of 20 to 30 pounds, between the heads of a suitable press, with key open, minus spillnut and washer. This test is for solidity of casting and uniformity of grinding at top and bottom lap or seal. The cock should then be dried, lubricated and assembled, after which it should receive the final inspection, which covers the assembling and finishing up, such as removing all fins, burrs, etc., and the general working condition of the cock. If this is satisfactory and the cock meets all requirements, the inspector should place the final inspection stamp upon it, preferably on the finished face of the hex. Records of the rejected cocks should be kept by the inspector.

Where the purchaser specifies a standard metal mixture, drillings for analysis should from time to time be taken from the keys and bodies.

Brass Valves

Owing to the number of good standard makes of brass valves, the general inspection of a submitted sample suffices for this class of material. The sample should be very carefully inspected for general construction, workmanship, finish and adaptation to the work for which valves are intended. Notes should be recorded by the inspector, so that any shipments about whose quality doubt exists, can be checked with the records of the sample valve, and if inferior in any way to the standard, the entire shipment should be returned.

Illuminating Appliances

General

As illuminating appliances and their parts are sold to consumers, it is essential to be certain that the material is in good condition and just as represented to the purchaser. This requires an individual inspection of fixtures, domes, portables and art glass shades, but other appliances may be accepted after inspecting only a portion of each invoice.

Special attention should be given to reporting material that is broken when received, as it is quite possible to recover for the damage to certain classes during transit.

Owing to the extensive variety of lighting material that is likely to be handled by a gas company in a large city, there is apt to be more or less confusion in ordering and receiving the different kinds, but this can be largely obviated by distinguishing numbers inserted on the appliance, after inspection, with a sticker or tag. A china-marking pencil is quite generally used on smooth glassware where a sticker will not adhere.

Fixtures

A great many fixtures are delivered unassembled, which materially aids inspection, and also prevents excessive breakage and tends to decrease transportation costs. However, fixtures from local dealers will generally be received completely assembled, as being delivered by their own teams, they do not require careful and expensive packing.

Cock construction is one of the most important features of a gas fixture, and all cocks should be purchased under the standard specifications of the American Gas Institute. (See page 608.) The inspection of the cock should be considered as the first and most important part of the fixture inspection. The fixture key gauge, Figure 64, page 195, should be used and the points to be covered are listed in the report form, Figure 281.

After this thorough inspection of the cock, a general inspection of the workmanship and construction of the fixture should be made, with a report of any defects and weak points. The fixture should then be placed on a gas line and subjected to a pressure of 3.3 inches of water column to test for obstructions and sufficient gasway. This is followed by an air test of 8 inches of water column to locate any defects or leaks, and the cock during this test should not contain an excessive amount of grease, and should be readily turned by hand. If the fixtures pass these tests, they may be approved and placed in stock.

Domes, Portables and Art Glass Shades

Owing to their cost, it is advisable that this class of illuminating appliances should receive a careful and individual inspection for cracked panels, defective solder joints, finish of brass work, and conformity to the requirements of the order. The inspection for cracks and defects in joints is best made by placing the glassware over an electric light.

FIXTURE INSPECTION REPORT

MADE AT .... DATE ....

MANUFACTURER .... ORDER NO. ....

FIXTURE NO. .... STYLE ....

MECHANICAL DEFECTS ....

....

....

....

.... COCKS ....

LOCATION AND NUMBER .... TYPE ....

CONDITION OF GREASE					LENGTH OF THREADS IN BODY				PLUG FORMED OF ONE PIECE OR HARD SOLDERED SECTIONS			KEY END SCREW END	
RELATION OF STOP TO MITRE	DIAMETER OF COCK BODY	THICKNESS OF METAL	BEARING SURFACE TOP	BEARING SURFACE BOTTOM	SEAL	GRINDING	GAS WAY (SIZE)	CENTERING	TAKE UP SCREW END	TAKE UP KEY END	KIND AND SIZE OF STOP	KIND OF WASHER	RECESSED

LOCATION AND NUMBER TYPE

CONDITION OF GREASE					LENGTH OF THREADS IN BODY				PLUG FORMED OF ONE PIECE OR HARD SOLDERED SECTIONS			KEY END SCREW END	

PRESSURE TEST ....

LEAKED AT ....

GENERAL ....

....

INSPECTOR.

Figure 281.—Fixture Inspection Report, page 904.
(Actual size, 5″ x 8″—loose leaf)

Glassware

Shades and globes should be inspected for proper position of designs and to insure a safe and perfect fit on the burner, and a collar opening large enough to allow a cylinder or chimney to slide readily through.

A portion of each lot of cylinders and chimneys received should be examined to check the style received and for fit on burners.

Mantles

A casual inspection of a portion of a mantle shipment should show whether the workmanship was standard, whether any changes had been made in the weave, and whether they hang straight and, if of the inverted type, properly fit on the burner tip.

Burners, Lights and Arcs

The constant changes in construction and style of this class of appliances necessitate the examination of a part of each lot received, to see that they are gas-tight, will pass sufficient gas to properly fill the mantles, and that the finish, etc., is in good condition and as ordered.

Fuel Appliances

Fuel appliances should be carefully examined for breakage, general condition, and missing parts; at least one from each lot received should be thoroughly gone over point by point to see that all the specifications are conformed with, as it has been frequently found that shipments do not agree in many essentials with the sample submitted for test.

A more ideal system would be to have inspectors visit the various manufacturers from time to time and inspect the appliances before shipment. In this way, a great deal of unnecessary trouble and work could be prevented, and, at the same time, the manufacturer knowing such inspection would be made, would take greater pains to conform to the specifications.

Cast-Iron Material

Pipe and Special Castings

The advantages of foundry inspection of pipe and special castings have been described on page 56. The "Standard Specifications for Cast-Iron Pipe and Special Castings of the American Gas Institute" should govern this work, but what follows should be of use to the inspector in enforcing this standard.

An inspector should have a general knowledge of foundry practice and be thoroughly familiar with the specifications by which he is to be guided; in addition, he should have a fair knowledge of the work for which the material is intended.

The inspector should be at the foundry before the first cast is made, and go over the patterns carefully to see that they conform in all respects to the drawings and specifications under which the contract is let. If unsatisfactory, the purchaser should be advised why, in the inspector's judgment, the patterns are unfit to be used.

In connection with the first cast of each day, it is advisable to have specimen bars cast for the purpose of making tensile strength test.

Upon the completion of all necessary cleaning and chipping, the pipe should be subjected to a close visual inspection, after which the sockets and spigots should be tested for size with standard gauges, and the pipe calipered at four opposite points of its circumference, at both bell and spigot ends for about twelve to eighteen inches, to determine the variation of metal thickness. After this, the hammer test should be applied for imperfections not discernible by the eye, such as honey-combing and blowing.

If pipe is cast heads down, the hammer test should be applied at the spigot ends. If cast heads up, the bell end should receive similar treatment; in addition, the face and socket of all bells cast head up should be well picked to determine whether any great amount of sand has floated to these points. Any pipe found to be defective from any serious cause whatever, should be rejected, the serial number removed, and any private marks of the purchaser also erased at this time. The inspector should immediately enter the number and the cause for rejection in his record book, to avoid any possibility of accepted and rejected pipe becoming mixed.

After this inspection has been completed, the pipe is ready for weighing and marking. The number, weight and inspector's initials should be clearly painted in white lead on the interior of the barrel at the bell end. The pipe is then ready for the hydrostatic test, before which the inspector should satisfy himself that the gauge on the press is correct and working properly.

When shipment is made, the inspector should check off all pipe loaded on cars to prevent any rejected pipe being accidentally placed therein. Schedules for shipment should be made out for each car and approved by the inspector in charge of the work.

The inspection of special castings should be the same as that for pipe, omitting the hydrostatic test.

Notwithstanding the closest inspection at the foundry, there are times when defective castings are liable to slip by the inspector, or it may be that in loading or in transportation they receive a jar or strain that would reveal a defect impossible to detect by the foundry inspection. It is advisable to have castings found defective after shipment inspected by an experienced person, to ascertain, if possible, the true cause of the failure.

Lamp Post Material

The foundry inspection of cast-iron lamp posts, ladder bars and panels has proved of great advantage. Formerly, manufacturers thought that standing upright was the sole requirement for a post and paid insufficient attention to strength and vital points of design. Foundry inspection insures the complete removal of cores and, therefore, an unobstructed passage for the lamp riser; the detection of variation in metal thickness causing weakness at critical points; the fit of ladder bars on post tops, preventing subsequent ladder turning with its possible serious results; the removal of fins and sharp edges, another hazard to distribution workmen; and conformity to prescribed weight.

Service Boxes

Experience shows that service boxes may be ordered from a sample without foundry inspection, and that the resulting stock will contain few defectives.

Miscellaneous Material

It is necessary from time to time to order quite a variety of miscellaneous material, such as sheet-iron pipe and fittings, leather or fibre washers, etc., and the advisability of having a local standard and of ordering in accordance with specifications cannot be too strongly urged.

Washers for unions, as an example, should be carefully inspected for thickness, quality of material and all dimensions, to insure their perfect fit on the unions. In fibre washers, which have been used to advantage for unions on water lines, it is necessary to allow $\frac{1}{16}$-inch in diameter of opening for shrinkage, as these washers are usually cut when damp.

Yarn is an article that should be inspected for the amount of dryness or oil content desired, as the case may be.

The value of specifications for oils has been demonstrated, and deliveries should be checked by periodic chemical analyses.

These items are selected from a long list to demonstrate the value of carefully inspecting material that may be classified as "miscellaneous." There is, however, another class of miscellaneous material not carried in stock, but specially ordered at odd times, and this also should receive at least a casual inspection.

Reclaimed Material

General

It is apparent that some economical disposition should be made of all recovered material. A great deal may be reclaimed and the expense of inspecting the old material and reclaiming that which can be used again is much less than the cost of the new material thus saved.

As the various kinds of materials require different methods of inspection, each class will be treated individually.

Fittings, Nipples and Steel Pipe

Each fitting need not be thoroughly inspected, but stripped threads, strained fittings and extensive corrosion should be watched for. Any doubtful inexpensive fittings should be scrapped, as the labor necessary for a thorough inspection and probable cleaning would exceed the cost of new fittings, less the scrap value of the old ones.

Brass Cocks

By reclaimed cocks are meant service and meter cocks that have been in service and removed. Unless removed for evident worthlessness, these cocks should be returned to the storeroom to determine whether or not they are in safe condition to be used over again. To begin with, they are thoroughly cleaned with a wire brush to remove all dirt from bodies and keys, after which they should be treated to a bath of boiling soda solution to remove all grease and foreign matter. All red or white lead should be removed from the thread and walls of hexes, after which the cocks are taken apart, keys and bodies wiped dry and lubricated. Any cocks showing signs of injury in grinding or elsewhere, either from use or a blow, are scrapped; those that appear to be in good condition are lubricated, reassembled and tested as a new cock would be. Those that are tight are placed in stock, and the others are scrapped. This reclaiming process should occur about once a year, and should be under the direction

of a cock inspector or any qualified mechanic familiar with the use of these cocks. By this means, large quantities of these cocks can be saved that would otherwise be lost.

Illuminating Appliances

Reclaimed illuminating appliances are inspected in the same way as are new appliances of the same type. This inspection ascertains whether by a nominal expenditure they can be put in shape to be sold as new, or at what price they should be sold in their present condition.

Fuel Appliances

In inspecting reclaimed fuel appliances, each appliance must be carefully gone over to ascertain its exact condition. When the number of reclaimed appliances is not large, their sale in a working second-hand condition may often prove advantageous as compared with extensive repairing in the endeavor to convert them into new appliances. In a large situation, however, there are many returned appliances, and experience shows that the trouble and delay in selling them as second-hand makes more economical the policy of converting them into new goods, either by the gas company or by the manufacturers. When this repairing is done by the gas company at different locations, standard methods of treatment are needed to insure a uniform product.

Cast Iron Material

Pipe and special castings taken out of the ground, unless of insufficient size, should be examined to determine their fitness for further use. If passed, they should be placed in the storeyard and used at the first opportunity. If condemned, they should be sold as scrap.

Miscellaneous Material

The advisability of inspection of the great variety of reclaimed material falling in this class becomes a matter of judgment, where the cost of inspection compared with that of the material itself is usually the determining factor.

Scrap Material

Materials under this heading have probably been inspected before, but in order to obtain a good price for scrap, it is well to separate it before sale into the following classes:

Brass:
- With iron pipe attached
- With lead pipe attached

Copper:
- Boiler tubes

Iron:
- Cast
- Sheet

Lead:
- Dross
- Pipe and joints
- Pipe with brass and iron connections

Rubber:
- Bicycle tires
- Inner tubes and trimmings
- Covered gas tubing

It can be readily seen from these divisions that some inspection is required to properly sort the material. In the case of brass goods, it is essential to know that the brass is not merely coating.

CHAPTER LXXXII

STORAGE

Introductory

As the design and layout of a storeroom depend largely upon the size and accessibility of the buildings and yard, it is proposed here merely to describe, in a general way, effective and time-tried methods of storing various classes of material. Throughout this chapter, floor carrying capacity must be continually kept in mind.

Bins, Closets and Racks

Construction

Bins and closets, as usually constructed, have been of surfaced lumber or sheet steel, of sizes to conform to the height of ceiling and the kind of material to be stored. Occasionally the wooden construction has been in portable sections, requiring more material, but allowing ease of moving. In the future, sectional steel bins, racks and shelving will find wider and wider use and ultimately replace wooden structures because of their advantages of adjustability, fire resistance, strength, convenience and operating economy. Some of what follows, however, has especial reference to wood.

By placing a partition lengthwise through the center, a row of bins or closets may be made into a double section, back to back, as it were, and saving considerable storage space over single rows. If feasible, aisles should be directly opposite windows, to admit light and ventilation, and should be ample in width to permit free movement of a workman with a hand-truck. Narrow aisle space not only causes the workman to carry what he would otherwise handle by truck or conveyor, but prevents the use of such labor-saving devices as mechanical computing scales, which, to be most effective, should be used at the bin.

The subdivision of bins and closets will be governed largely by the character of material, but a general rule to follow is to make

the compartments at the bottom large enough to accommodate heavy or bulky material, and to decrease the size with the height. Assuming that the bins on the bottom are three feet square, at the top of the first tier the depth would be reduced by one board at least one foot wide. This would afford a footway along the entire length of the first tier, thus making bins at a height of eight or nine feet accessible without the use of a ladder. This point is of interest to the storekeeper because of the objections to ladders for obtaining material. Light scaling ladders, placed at an angle against the bin, are more or less hazardous, because the men, to save moving the ladder, take chances by leaning far to one side, and in consequence, the ladder often goes with them to what sometimes results in a serious injury. Another objection is the difficulty of finding a safe as well as a convenient place for the scaling ladder while not in use. If it is left standing in an aisle, a workman engaged in trucking material is very apt in turning a corner to strike it, causing it to fall either against himself or another workman. Step ladders are more or less cumbersome, especially in view of the necessity of moving them from place to place, but where ladders are required, a strong type of lightweight ladder seems to be the most satisfactory in the absence of ladders on trolleys.

All bins should have a board or strip across the front, not less than three or more than twelve inches wide, to hold in material and to provide name space.

Racks or shelves may be constructed of steel pipe, tied in at the bottom by floor plates and at the sides and top by fittings with cross pieces of planking, on which may be stored tools, such as shovels, bars, handles and other large tools. By the use of storage racks or platforms built at an elevation half way between the floor and ceiling, storage space for that area may be doubled. These racks are of service in utilizing space directly over material which cannot be piled to advantage.

Labeling

On any floor, each row of bins, closets, racks and shelves should be designated as a section, and lettered in alphabetical order beginning with the letter "A," and each bin numbered in numerical order beginning with number 1, for each section. Attached to either the closet door, or to the strip across the front of the bin, should be a metal card-holder about 3 by 7 inches, containing a bin card, Figure 270. The section letter and bin

number should be recorded in a stock ledger so that anybody in the organization can locate material by reference to this record. This will avoid the confusion incident to locating stock in the absence of the order man.

With the work of putting away and getting out stock in the hands of a few men who have been allowed to do it in their own way, however conscientiously and reliably, there will be all manner of confusion in locating stock in their absence. Where two or more men are employed, it is advisable to train them to be interchangeable, so that no particular branch of the work will be dependent upon one certain workman.

Storage space for each item should be based on the maximum stock, as it is better to have a few bins out of use occasionally, than to so use space as to result in much changing about or scattering the stock in several places.

Steel Pipe, Fittings and Nipples

For accessibility, all pipe should be stored, by size, under cover, in suitably designed racks, located at or convenient to roadways. One end may be piled even for good appearance, and it is well as a timesaver when inventorying, to divide large lots with chain into piles of, say, 2000 feet. Skids or blocking should be placed underneath the pipe to keep it off the ground. Coated pipe should be kept preferably under a shed with one or both ends open to admit air for quicker drying. Lath may be used on the flooring and between each layer of pipe, as it must be kept from sticking together. Threaded ends exposed to the weather should be sprayed with oil, of a composition recommended by the pipe mill.

The recommendation to provide space for the maximum stock of each particular article is not feasible or economical in the case of large stocks of fittings, where as many as 100,000 of one size are used in the course of a year. Therefore, evolution has brought about the storage and handling of such stocks in original barrels and cases. This refers to any part of a consignment which includes barrels containing only one size of fitting or nipple. A proper record is kept of all barrels with such contents, and little or no trouble is experienced in locating or handling such material. The contents of all barrel lots are marked plainly on the head of the barrel.

All other fittings are kept in bins varying in size according to the size and quantity of the material. Nipples 4 inches and shorter, with the exception of barrel lots, are stored loose in bins,

while larger nipples are piled neatly in rows. In allotting space for piling nipples, guard against such lost space as would result, for instance, in piling nipples 10 inches long in a bin 24 inches deep. There will, of course, be places where nipples whose length bears an even relation to the depth of bin cannot be used.

Illuminating Appliances and Parts

All of this material is fragile and valuable, and needs protection from breakage, deterioration and theft.

Arcs and Globes

When used in sufficient quantity, arcs and arc globes should be purchased in cartons, as the increased cost thus caused will be more than offset by reduction in breakage. Each unit is packed in individual cartons, a convenience in handling in the storeroom and in transit to the consumer. The cartons are packed one to two dozen each in skeleton wooden cases, and may be piled and sent out in the original package.

Domes

The history of storing domes is replete with breakage, and it might be of interest to repeat the various methods that have been used.

Storing in casks or boxes, completely enveloped with hay or excelsior, affords protection, but requires much space, and affords no means of ready recognition for stock taking and filling orders. Laying the domes on shelving, accessible and convenient for other storeroom purposes, is not satisfactory, because vibration and atmospheric conditions cause breakage, partly due to the uneven edges of the bearing surface supporting the full weight of the dome.

The problem, therefore, seems to be to devise something which will withstand vibration and the expansion and contraction of glassware, and the arrangement shown in Figure 282 has been very satisfactory. Attach with floor flanges, two pieces of $\frac{1}{4}$-inch steel pipe, one to the floor and one to the ceiling, leaving one foot of open space between the two ends; then, over the lower pipe, slip a $\frac{1}{2}$-inch nipple long enough to suspend a dome 3 inches above the floor. The dome is equipped with a standard spider through the opening of which no larger than $\frac{1}{4}$-inch pipe will pass, so that the spider and dome rests securely on the $\frac{1}{2}$-inch nipple. Insert another $\frac{1}{2}$-inch nipple to support dome number two, and so on up to five domes, keeping about 3 inches play between each dome.

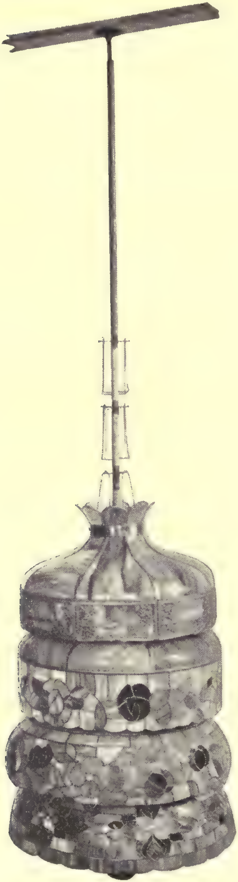


Figure 282.—Dome Storage Rack, page 915.

The rigidity depends upon the use of a $\frac{1}{2}$-inch nipple about 18 inches long which connects the two $\frac{1}{4}$-inch pipes. This nipple rests on the top of the last spider and should be long enough to engage the $\frac{1}{4}$-inch pipe attached to the ceiling. This method requires very little space.

Fixtures and Casing

All polished or specially finished parts should be wrapped with tissue paper to protect the finish, and then tied up securely with wrapping paper. Where there is sufficient headroom, fixtures may be suspended from a pipe or rod attached to the ceiling, using a chandelier hook in attaching the fixture to the support. Brackets can be piled to advantage, but never pile fixtures having arms.

Box Lights and Mantles

When shipped in sealed cartons and used in large quantities, box lights and mantles can be stored in original cases. Broken lots, however, should be kept under lock and key. Owing to the marketable nature of this material, every precaution should be taken to guard against theft.

Portables and Shades

These are wrapped up to protect metal finish from tarnishing and scratching, and may be stored in bins large enough to accommodate the portable standing on its base. Companion shades and portables are kept together.

Tubing

This refers to so-called rubber tubing for appliance connections, which, if not cared for properly, will dry out and deteriorate very quickly. It should be freely ventilated and never stored in closed compartments. Keep it laid out flat on low shelving of the skeleton type, and do not pile in too many layers. Tubing may be stored on large spools, but an objection to this is that the bottom lengths are subjected to too much weight, and become pressed out of shape.

Fuel Appliances and Parts

Up to the limit of floor carrying capacity, fuel appliances may be piled on top of each other, either crated or uncrated, except such cabinet ranges as are too large to be piled safely. In piling uncrated ranges, use at least two strips of wood about 1 inch thick and 4 inches wide across the top of ranges, one at front and one

at back, to act as a bearing and to keep the ranges piled evenly. Automatic water heaters may be kept in original crates and piled, as may gas heaters received in cartons. Water heaters may be piled in rows with a light strip of wood between each tier. When unloading a carload of ranges, save all wooden strips which act as supports or braces in the car, to serve in piling ranges for stock. Large units, such as hotel ranges, bakers' ovens, large broilers, storage-type water heaters, etc., which cannot be piled to advantage, should be stored underneath open racks, already mentioned, the top of the racks to be used for high shelves, range bodies, canopies, and for bins and closets in which provision may be made for small appliances, such as stovelighters, toasters, sad-iron heaters, chafing dishes, percolators, and gas irons. These small appliances should be kept under lock and key, with the responsibility of handling them limited to certain men, so that any discrepancies may be traced.

Fuel appliance parts may be stored in bins of varying sizes to accommodate the different parts. Preservation of nickel and sheet metal parts is effected by greasing with petrolatum and painting with flexible compound or any antirust solution. This is not necessary in the case of new appliances, because the manufacturers have been educated to wrap with paper all nickel parts, and to oil the sheet metal parts, but it is essential to go over stock which may be carried over from one year to another.

Cast-Iron Pipe and Specials

There has always been a tendency to regard the sizes of special castings as being readily distinguishable by the eye, and, in consequence, the wrong size, especially in large castings, is frequently sent out. Therefore, it will pay to mark the size on all castings not so marked in manufacture. This is particularly important for caps, plugs, split sleeves and reducing specials.

This material is usually stored out of doors, and often with little or no attention paid to the first arrangement or subsequent placing. This results in disorder, delay in filling orders and loss of valuable storage space. Cast-iron specials should be kept in alignment according to kind and size, and piled, if feasible. In piling pipe, insert boards between each tier and tie in the end pipe with wedges to prevent slipping off. There should be sufficient driveways in and around the yard, and each lot of material should be accessible at all times.

Combustible and Inflammable Material

This class includes all oils, matches, paints, liquid polish, excelsior and waste. Observe all the fire underwriters' rules concerning them. Gasoline is kept in a galvanized tank placed outside in a concrete cradle three feet underground, and is pumped by hand. Coal oil, lard oil, alcohol, linseed oil and turpentine are stored in outside fireproof vaults, and are drawn up by air pressure. Excelsior, hay, matches, clean waste and yarn may be kept inside the building when stored in wooden boxes lined completely with at least No. 20 gauge sheet metal. All loose hay, excelsior and old paper is baled or removed from the building. Cans with self-closing lids should be provided for greasy waste used inside.

Miscellaneous Material

Sundry Material

Brass cocks, bicycle sundries, brushes, chisels, pliers, wrenches, etc., are usually kept under lock and key in closets to which only certain men have access.

Great care should be exercised in keeping this stock in order, as the mixing, in one bin, of parts of tools and various sizes of small cocks will result in much loss of time.

The closets are partitioned off according to the size and stock of article; a feature of this work, and one which is generally used for all material stored indoors, is an "in" and "out" card, which shows the inventory as of the close of the year, together with the quantities put in and taken out from day to day. By balancing this card, the quantity on hand can be readily determined. This, however, only applies to main storeroom practice, as it would not be practicable where material is issued in small quantities direct to the workmen.

Sheet Metal Flue Material

This class of material should be stored under cover, free from dampness, and coated with an antirust solution.

CHAPTER LXXXIII

ACCOUNTING

General

In this chapter will be described approved methods of storeroom accounting, these including cost of material, stock records and reports, stock balances, issuing material, compilation of operating costs, distribution of handling charges, taking inventories and adjusting discrepancies.

It is a general truth that no system should expend more in accounting for an article than the worth of the latter; therefore, stock cards and account sheets, fully justified for valuable and marketable material, should not be used for items of little value, in a slavish adherence to a system. Material such as printed forms and stationery, articles purchased for specific work, and inexpensive miscellaneous things which cannot be easily weighed or counted, should be charged out when ordered and not be accounted for as used in small quantities from time to time. This is further discusssed on page 927 under "Material Accounted for in Bulk."

Where the volume of work justifies the expense, the largest situations should consider the use of tabulating machines for sorting and summarizing orders, thus gaining accuracy, saving labor, and greatly shortening the time for report making. However, as each such system must be especially devised to take care of local conditions, it is thought a general description of the fundamental principles of storeroom accounting by hand work, applicable to small and large situations, will be more serviceable.

Cost of Material

Passing Invoices for Payment

The purchasing agent's order should contain an explicit notice where to forward all invoices. These are usually sent in duplicate to the purchasing agent, who keeps the duplicate and for-

wards the original to the main storeroom to be checked with the quantity received, and finally approved and passed along for payment. The purchasing agent certifies on each invoice that it has been checked as to price, but the storeroom bill clerk should also see that the price is in line with previous purchases or present market values, and if not, call attention to the difference.

All invoices should be stamped by the bill clerk with the date of arrival, as their prompt approval is advisable, and with the time of receipt unknown, an invoice may be held up indefinitely with little chance of placing responsibility for delay. This is important where time discounts may be lost through negligence. For ease in tracing missing papers, invoices should not be forwarded from one office to another except through designated channels. In all cases a copy of the purchasing agent's order should be forwarded to the office responsible for passing the invoice.

The copy of the purchasing agent's order is held by the receiving clerk until receipt of material, when the date and quantity received are posted (see page 887). After checking extensions, the invoice is then compared with the information furnished by the receiving clerk, and if the quantity called for on the bill agrees with that received, the invoice is classified and passed for payment. The date, amount, classification and date of approval of each invoice is entered on the copy of the purchasing agent's order, as this information is very essential as a matter of record, especially so in checking duplicate invoices.

After satisfying himself that the invoice should be passed for payment, the bill clerk classifies it to the proper account, as shown by the receipt or the copy of the purchasing agent's order. In case the invoice is classified direct to an operating account, it is submitted to the superintendent for approval and sent to the comptroller. If classified to "Storeroom," it is entered in the material purchased book and on the stock ledger before being signed and forwarded to the comptroller.

Upon receipt of a duplicate or triplicate invoice, the copy of the purchasing agent's order is referred to, and if this shows a clear record of passing the original, stamp the duplicate or triplicate copy "Storeroom has passed bill on ....(date)........, same date and same amount," which will guide the comptroller in locating the original. In case the original has not been passed for payment state "Storeroom has not passed bill before." A record of the duplicate or triplicate should be made alongside

that of the original, as by such recording there is little chance of double paying.

SHOP WORK COST RECORD

.... DISTRICT DIVISION REQ. NO. .... DATE ....

SHOP ORDER NO. ACCOUNT

QUANTITY	MATERIAL	PRICE	COST
	TOTAL MATERIAL COST		

WORKMAN	RATE												TOTAL HOURS	COST
TOTAL LABOR COST														
TOTAL COST OF WORK														

Figure 283.—Shop Work Cost Record, page 923.

When material is returned for credit or replacement, the bill clerk should exercise as much care in checking for price and quantity as he does for material received.

Freight bills are particularly troublesome to pass, because it is advisable to associate each consignment with its purchasing agent's order, especially when the freight is charged back to the shipper. The freight bill usually calls for, say, two cases from a certain railroad station, with no other guide than the date, so that it is absolutely essential to keep the accurate record of all freight consignment, as already explained on page 887.

The terms "F. O. B. Point of Shipment" or "F. O. B. Destination" should be inserted on all freight bills as a guide to the comptroller.

Manufacturing Material for Stock

In making bicycles, meter connections, tools, or nipples, or where labor is required to complete an unfinished article, such as assembling fixtures, a shop order, Figure 283, is originated to cover each lot of material. This system can also be applied to the operation of a carpenter shop, by which all shop expense, such as labor, power, rent, etc., should be charged to "Storeroom" account and closed into various accounts for which work was done, or charged against the stock material created.

The shop orders should be numbered serially and describe the work to be done. The number affords a ready means for reporting labor and discussing details about any order. These orders should be made out in triplicate, the original sent to the shop, the duplicate kept by the stock or order clerk, and the triplicate sent to the accounting division. All material and labor is reported by order number. When the work is completed, the date and the signature of the foreman is entered on the original order and returned to the order division. At the close of each month, a final statement is made showing the total cost of labor and material on each completed order.

Appraisal of Reclaimed Material

All returned appliances, whether in need of repairs or not, should be debited to the stock account at their full value, charging the proper sales account with the cost of repairs or the entire value beyond repair. The alternative method of fixing a certain percentage of the original cost as the value at which returned appliances are charged into stock, is not to be recommended, not only from the difficulty of determining the real value

of a used appliance, but also because of the fluctuation made in stock unit prices.

Miscellaneous material, such as cocks, fittings, cast-iron pipe, lamp posts, special castings, etc., that have been accepted as being reclaimable, and of the need for which there is a reasonable certainty, should be placed in stock and credited at the prevailing unit price, less the expense of labor and material that may be required to put them in good condition. Based upon the assumption that returned material is not worth as much as new stock, one might fix an arbitrary credit valuation at less than cost, but, as in the case of returned appliances, it is advisable to appraise at somewhat near market value, thus obtaining uniform stock prices and operating costs.

Unit Cost

The unit cost is used as a basis for selling prices, appraisal of stock, and for compiling operating costs. It is obtained by dividing the total quantity received (of one or more lots) into dividend of charges which may include any one or more of the following items: net invoice of dealer, manufacturing cost of a company-made article, freight or expressage, labor and hauling, and in the case of reclaimed material, appraisal value. There is a practice of closing freight or expressage and cash discount into the handling accounts, not only to simplify the clerical work, but because the freight charges about equal the cash discounts. This is not recommended because it is wrong in principle to close into the handling account any item not directly related to the handling of material, and, especially when no discount is allowed, the error involved may be considerable.

Issuing Material

General

Success in this work requires cooperation between the storekeeper and any one having to do with the use of material, to the end that a reliable record of material used may be furnished and loss of material held to a very low figure. Too much stress cannot be laid upon the necessity of having a definite understanding with all concerned that no material should be issued from the storeroom unless on presentation of a written order, except in the case of certain material, such as matches, white lead, solder, twine, etc., the reporting of which as used on each

job would be not only impracticable, but too costly. The orders that will be described are those in use in Philadelphia.

Orders for which material is required are originated either by the commercial department from sales orders covering sales of specified articles to consumers, or from local instructions usually in the form of authorizations, calling for the extension of mains, services and meters, or the enlargement of services and meters due to the sale of fuel appliances.

Sales Order

This order (see Figure 190, page 664) is used to authorize the installation of appliances or repair parts sold to a consumer, and is sent in duplicate by the commercial department to the shop. In order to prevent the workman from making any change in the amount of material shown, the original order is sent first to the storekeeper, who issues the material and then hands both to the workman. As each article is taken from stock, the storekeeper stamps the order "Issued (date)." If only a part of the articles listed on an order are issued, the stamp may be placed opposite each such article, or a "not issued" stamp may be placed opposite each one not issued; otherwise the stamping on the back of the order should be understood to indicate a complete issue. Returns are indicated in a similar way.

The duplicate orders are filed in the shop pending the completion of the work. When the original has been finished and returned by the workman, the corresponding duplicate is removed from file and then both are sent to the storekeeper, who audits them to see that they agree exactly as to work done. This is important, because the original is returned to the commercial department and is used for billing the consumer, and the duplicate to the accounting division where it serves as a notice that the articles thereon have been issued from stock. This duplicate, in addition to the issues, should show the address, order number, date of audit, and account classification. An added precaution to prevent loss of orders, is to give a serial number to each original and each duplicate order as it is sent away from the shop.

Credit Order

This is an order issued by the commercial department to remove an appliance from consumer's premises after it has been installed. Its principles of use and its subsequent audit are the same as those for the Sales Order.

Material Order

This order, Figure 284, is used to report material as apart from appliances or their parts. A separate form for each class of work requiring distinctive material will obviate unnecessary printing

METER, HOUSEPIPING, AND APPLIANCE MATERIAL USED

ADDRESS...ST. ....191......

USE ONE SHEET FOR EACH DIFFERENT KIND OF WORK DONE

MATERIAL	NO.	SIZE	NO.	SIZE	MATERIAL	NO.	SIZE	NIPPLES NO.	NIPPLES SIZE	NIPPLES LENGTH
PIPE					ANTI-FLUCTUATORS					
PIPE					ARC BRACES					
PIPE					ARC COLLARS					
BUSHINGS					ARC DRIPS					
CAPS					FLUE COLLARS					
COCKS					FLUE CROCKS					
COUPLINGS					FLUE DAMPERS					
COUPLINGS					FLUE ELLS					
CROSSES					FLUE PIPE					
ELLS					FLUE REDUCERS					
ELLS					FLUE TEES					
SERVICE ELLS					FLUE HAT FLANGES					
45° ELLS					DRAFT HOODS					
DROP ELLS					BRACKETS					
TEES					BOX BACKS					
TEES					CASING					
TEES					CANOPIES					
TEES					TAIL PIECES					
SERVICE TEES					BOILER SPUDS & COUPLINGS					
PLUGS					CEMENT		QTS.			
LONG SCREWS					TUBING 5/16"		FT.			
UNIONS (NOT METER)					TUBING ½"		FT.			
CORBETT-STEVENS Meter Connections					TUBING GAS IRON					
METER UNIONS					TUBING METALLIC					
METER SHELVES										
VALVES										
PIPE HOOKS					ACCOUNT					
PIPE STRAPS					WORKMAN			STORE ROOM NO.		
PIPE HANGERS					FORM 747A.			CITY		

Figure 284.—Material Used Record, page 926.
(Actual size, 7¼"x8½"—loose leaf.)

or writing on any one form. A duplicate copy of this order will serve as a delivery sheet for driver. Each order is classified by the storekeeper, or the account is checked by him if classified by a workman.

After an order is written, no alterations should be made except to cross out an item entirely or to reduce the number of an article. This should be done by making a pencil mark through the original figure and substituting another figure beside it. If more material was used than the order shows, it may be added to its face, provided there is a vacant space; otherwise, an additional order should be filled in for the additional material. A figure should never be increased by erasing it or making a pencil mark through it. Orders showing alterations should receive the special attention of the storekeeper.

All orders should be turned in to the office for numbering before being sent to the storekeeper. This numbering prevents the loss of orders and shows the issuing of the material has been approved by the office, and except in specifically authorized cases, the storekeeper should not supply the material until the order is numbered.

All orders should be examined by the storekeeper so that he may know the material has been properly reported, and that they contain all data required by the accounting division.

Workman's Stock

Some men are permitted to carry a supply of certain material, a list of which is kept by the storekeeper. When a workman uses any of this material, he lists it on a storeroom order and turns in the completed work order with the storeroom order attached, to the clerk, who numbers both orders, after which the former passes through the office in the regular way, and the latter is sent to the storekeeper, who reimburses the workman for the material used from his stock. In this way the workman is responsible for a certain quantity of material which should be checked by the storekeeper at odd times. An alternative method provides for giving the workman a freshly filled box each day, and having him turn in his depleted stock daily to the storekeeper with the work orders on which the material was used. The storekeeper checks the work orders against the missing material to see that all has been accounted for.

Material Accounted for in Bulk

On page 920 certain material was instanced which can not be charged out as used on each job. This class may be charged out when ordered, dividing the quantities proportionately among the accounts for which the material is ordinarily used. This division should be governed by a table showing the average

percentage by accounts of the use of this material, the table being based on actual use, and revised quarterly.

The following material belongs to this class:

Acid	Nails
Alcohol	Oil
Ammonia	Paint
Asphaltum	Plaster of Paris
Bakelite	Putty
Candles	Rosin
Canvas	Sal Ammoniac
Cement	Sand
Clay	Screws
Cleaners	Skins, chamois
Cloth, emery	Soap
Cleats	Soda
Coating, pipe	Solder
Coke	Tallow
Enamel	Tar, pipe coating
Gravel	Tin
Grease	Tubing
Grit	Turpentine
Lead, red and white	Twine
Lumber	Varnish
Matches	Washers
Mercury	Waste
Muslin	Wire

Parts for all arc lights, excepting globes, mantles, ceiling shields, magnet valves and shades.

Parts for box lights, excepting mantles, shades, globes, cylinders and chimneys.

Returning Unused Material to Stock

When a workman uses less material than has been delivered on a preinspection order, or than he has drawn on a material order, he turns it in to the storekeeper with a credit storeroom order. Where the standard box system is in operation, or, in fact, wherever there is a likelihood of any material being unused and left on the street or the consumer's premises, the storekeeper, to insure its collection, should list the name and address opposite the number of each box delivered, and check it off upon the

return of box to the storeroom. This list should therefore show at all times the number of boxes outstanding.

Breakage

All breakage of mantles and glassware on consumer's premises should be charged out to the account on which the workman is engaged at the time.

Any accidental breakage that cannot be charged out to a particular job, such as material broken when received from dealer or railroad station, for which no claim can be made, glassware found broken in case lots, and that broken in the storeroom by workmen or otherwise, should be reported to the main storeroom at the close of each month, when it may be summarized by units and value according to the unit stock ledger costs. The value of this breakage is then apportioned to the accounts to which material of the class broken would ordinarily be charged. The object of determining the total cost of breakage is to find the ratio of value of breakage to the total issues of that class of material, so that it may be included in the selling price.

Another method of disposing of breakage is to decrease the unit quantity from the stock ledger sheet, thus increasing the unit cost. This practice has the disadvantage of frequently altering the unit price and making it no longer correspond with the real cost of the article, which tends to confusion in checking costs.

Checking Material to Avoid Loss

Without going to unnecessary expense, storeroom material should, by some simple system of checking, be protected against loss. Individual accounts may be kept with certain workmen if, from comparing the material orders on which, say, cocks were drawn with the number of cocks as reported on completed storeroom orders, there is reason to believe they are responsible for loss of material. The preinspection plan of delivering only enough material for each job will be found to be a more effective check against loss through collusion or carelessness, as the workman must furnish good reasons for drawing additional material, which, of course, is added to the storeroom order. By having an inspector make the preinspection and list what is wanted, and a fitter and helper do the work, while the storekeeper holds the duplicate order to be compared with the original after the job is completed, it can be readily seen that the storeroom is fairly well protected against loss.

Stock Records and Reports

Material Purchased Book

This is a loose-leaf book, Figure 285, in which are entered the bills classified to "Storeroom." This record is kept for the purpose of checking bills and balancing monthly the storeroom stock

STORE ROOM MATERIAL PURCHASED

MONTH 191

INVOICE NUMBER	DATE	FROM WHOM PURCHASED	AMOUNT	ENTERED	ENTRY CHECKED	REMARKS

Figure 285.—Material Purchased Book, page 930.
(Actual size, 11″ x 12″—loose leaf)

account with the comptroller's balance. By keeping this record according to classes of material, that is, keeping each class separately, the total amount of each class purchased may be gotten by simply adding the total amount of the bills entered in any

month. Each bill is numbered, beginning with number one for each year for each class of material, the number being entered in the book, to afford a ready means of checking between the storekeeper and comptroller. In this book should be posted everything in the way of petty cash and labor chargeable to

STORE ROOM MATERIAL LEDGER

SELLING PRICE ....

NAME OF MATERIAL .... RETURN PRICE ....

INVOICE NUMBER	DATE RECEIVED	ORDER NUMBER	GROSS UNIT PRICE	DISCOUNT	QUANTITY RECEIVED	NET UNIT PRICE	NET TOTAL COST	REMARKS	DATE ISSUED	QUANTITY ISSUED	UNIT PRICE	TOTAL COST	REMARKS

Figure 286.—Material Ledger, page 932.
(Actual size, 11"x15"—loose leaf)

"Storeroom," together with all credits. As each bill or item is posted on the material ledger, it should be checked off in the purchase book.

There are companies which keep, in place of the above record, an ordinary scrap book, into which an extra copy of the invoice is posted, the amount of each bill being carried to a column ruled on the right-hand side of each page. The total value of goods purchased is found by adding this column, while the individual

items, quantity and value are of course shown on the bills. This method is somewhat cumbersome, and copies are likely to become detached and mislaid.

Material Ledger

This is a unit loose-leaf ledger, Figure 286, containing a separate sheet for each kind of appliance and for each kind and size of article chargeable to "Storeroom," except reducing fittings, which are grouped by their largest opening, and material such as nipples, pipe hooks, washers, etc., which is grouped by class but not by size. However, items which vary greatly in price should not be grouped.

In this ledger, each item on the invoice is posted on the debit side, showing date of receipt, invoice number, quantity received, terms of invoice, net unit cost and total cost. On the credit side should be shown the date of issue, quantity sold and value of each lot issued. By balancing these sheets, it is always possible to determine how much stock is on hand, although allowance must be made for outstanding invoices or credits. A space should be provided on each ledger sheet to show the selling price to outside parties, as the unit stock price fluctuates for various causes, and it is better to use a uniform figure; also show the minimum and maximum quantities to be carried in stock, and enter on the sheet the number of the bin in which the article is stored. In this way there is an office record of the location of each article.

The ledger clerk, as well as the bill clerk, should at all times watch the unit cost of material, and where he finds a wide variation from the cost of the previous purchase, he should notify the purchasing agent.

Summary of Issues

Just as the record of the value of material purchased should be kept according to well-defined classes of material, in order to ascertain the investment in stock for each class of material on hand at the close of each month, so should the issue be recorded on cost sheets that are ruled and printed for each classification of accounts and for each class of material for which a separate material ledger is kept. By this method the stock investment of any class of material may be obtained without going to the expense of balancing each ledger sheet.

All material orders and other authority for issuing material should first be separated and grouped for each classification and

MATERIAL ISSUES — GENERAL
COST SHEETS 1

				TOTAL	PRICE	AMOUNT
Blocks, Spruce	1x8x8					
" "	1x12x12					
Box Backs						
Boxes, Service	Short					
" "	Long					
" Ext. Pieces	No. 49					
Brackets, Stiff						
" S. S.						
" D. S.						
Bricks, Red						
" Vitrified						
Bushings	¼					
"	⅜					
Etc.						

Figure 287.—Material Issues, General, page 934.
(Actual size, 8½"x11"—loose sheet)

then entered on a cost sheet, Figure 287, which contains an itemized list of standard items in the left-hand column and ample space in the center for posting the quantity issued, the entries being made from day to day to save time at the close of

FUEL APPLIANCE ISSUES

APPLIANCES	DISTRICT STORE ROOM		DISTRICT STORE ROOM		TOTAL UNITS	TOTAL AMOUNT	
	UNITS	AM'T.	UNITS	AM'T.			
TOTALS							

Figure 288.—Fuel Appliance Issues, page 935.
(Actual size, 11"x14"—loose sheet)

the month. A similar form is used for credits, which should be stamped, in red ink at the top, "Credit," although, if few in number, credits may be entered in red ink on the regular charge sheet, to be deducted when making the final total. To insure accuracy the individual credit sheet is preferred.

Where costs are kept for more than one shop for each classification, a summary sheet, Figure 288, is used, to which the entries

STORE ROOM BALANCE SHEET

GAS DEPARTMENT

quarter ending ______________

	STORE ROOM BALANCES AUTHORIZED	PRESENT STORE ROOM BALANCE
Street Main Materials		
Small Wrought Iron Pipe		
Small Fittings, Cocks, Etc.		
Gas Appliances		
Gas Fixtures Welsbach Material		
Duplicate Repair Parts, Works		
TOTALS		

"Store Room Suspense Account" Balance ______________

Figure 289.—Balance Sheet, page 936.
(Actual size, 8½"x11"—loose sheet)

are transferred from the individual cost sheet. A small issue may be entered directly on the summary sheet, thus obviating the expense of making an individual cost sheet for each station.

To ascertain the total amount to be charged against each account, every item is extended on the cost sheet, then totaled, after which the quantity issued and the value of issue of each item is posted on the credit side of the material ledger. The total amount charged to all accounts is credited to "Storeroom" account by a journal entry at the close of each month.

Stock Balances

In maintaining a stock according to the rules discussed on page 865, the storekeeper will be aided by a division into the following classes:

(*A*) Street Main Material
(*B*) Steel Pipe
(*C*) Fittings, Cocks, etc.
(*D*) Fuel Appliances
(*E*) Illuminating Appliances

For the first four classes, the largest stock would probably be carried on March thirty-first and the smallest on December thirty-first, while that under "E," owing to most of the lighting material being used during the winter months, would be largest on October thirty-first and smallest on June thirtieth.

A statement of storeroom balances, Figure 289, divided into the several classes, should be sent in quarterly to the distribution head, and the storekeeper should, even though the balances are within the amounts authorized, analyze the purchases and issues in order to attain better results if possible.

Comparison of Stock and Issue

By keeping a record of issues according to classes of material, comparisons may be made as to the ratio of stock on hand to the amount issued; for instance, an issue of $100,000 during the entire year and a stock of $25,000 at the close of the year, is a ratio of stock to issue of 25 per cent, which, if the material is all active, is equivalent to carrying three months' supply.

After analyzing the total amount of issues and of stock balance for each class of material, the next step would be to analyze the activity of each article by comparing the quantity issued with the quantity on hand, which may be done, preferably, immediately after the close of the annual inventory, or from the stock ledger at the close of each month. If dissatisfied with the ratio of stock to issues, set a hypothetical figure of, say, 20 per cent in place of the actual figure, and then make up a list of all stock items by classes of material which show more stock on hand than 20 per cent of the total issues. By this method you will have learned the activity of each article and be in a position to report the absolutely "dead" stock.

Stock Deterioration

This question is a factor that enters into the operation of a storeroom, especially where gas fixtures and fragile material are

handled. While many salable articles are marked down and sold "As is," it is thought advisable in many cases to have a stock fixture refinished, the expense being charged either to the proper operating account, or to a "Stock Deterioration" account. By following the latter course, one is enabled to learn the total expense of this work, and also periodically charge off from "Storeroom" any stock material that deteriorates to the extent of being worthless, the total "Stock Deterioration" afterwards to be closed into the proper operating accounts.

Other stock material, such as rubber tubing, steel pipe, flue material, etc., will be condemned from time to time, and where large stocks are carried, it is an easy matter to deduct the unit quantity condemned from the stock ledger sheet, thereby increasing the unit cost without changing the money value.

Suspense Account

To this account should be charged all dead stock, crediting "Storeroom," thus eliminating from it the value of such dead stock. At the close of each year "Suspense" should be revised by charging against it any additional items of dead stock, and crediting to it any dead stock that may have been used or sold. The value of "Suspense" should be shown on all reports of storeroom material balances. Efforts should be made to dispose of dead stock by sale or otherwise.

Inventories and Discrepancies

Taking Inventories

Inventories furnish an absolutely necessary check upon the relative accuracy of any system of stockkeeping, issuing and recording. They show what differences may exist in both stock units and values between the actual stock and the book records. Such a check is, of course, most important where articles are sold and there may be a failure to render proper bills.

It is not advisable to take too much for granted and expect good results from an annual inventory, unless monthly check inventories are taken all through the year to get a line on any probable discrepancies. The items should be so selected that some kinds of material are inventoried once during the year, some kinds several times a year, and some every month, the articles inventoried every month being marketable and valuable material in which discrepancies are most likely, such as brass goods, lamps, mantles, etc. At the same time it is well to bear in mind the cost of inventorying and not incur undue expense.

Where large purchases have been made with a comparatively low issue, the storeroom bookkeeper should indicate such items for monthly inventory, in order to ascertain whether there is really an overstock, or whether the material has been used and not accounted for.

Most companies have adopted the continuous inventory plan, whereby material is counted and checked when it is least active, which not only insures a more accurate inventory and accounting of issues than would be the case if an inventory was taken during a peak load, but also distributes the work over three or four periods throughout the year instead of trying to accomplish it all at one time. The following inventorying dates are recommended:

Illuminating Appliances . .	Close of June
Cast Iron and Miscellaneous	" " October
Fuel Appliances and Parts .	" " November

When calling for a monthly or annual inventory, the storeroom should forward an itemized list of the material to be inventoried, and the time of inventory should be the close of business on the last day for counting issues for that month.

Workman's stock, cast-iron pipe and specials on the street, and all appliances which have been delivered but not yet connected at inventory time, should be included in the inventory.

Many discrepancies have been finally traced to errors in counting the material or in compiling the totals, so that every one responsible for storeroom stock should bear in mind the unnecessary labor caused by these errors. As a matter of fact, in a large situation it is almost impossible to trace all discrepancies, and those due to inventory errors, if not corrected, will appear the succeeding year in the opposite column. In other words, if the inventory balance at the close of 1918 includes an item that was plus 50, due to an error in counting, this same item will be minus 50 at the close of 1919.

Comparison of Inventory with Ledger Balance

Before comparing the inventory with the ledger balance, all outstanding invoices for material received prior to date of inventory, or for material which has been included in the inventory, should be added to the general ledger balance or deducted from the inventory balance. The invoice clerk should make up a list of all such bills showing kind of material, date and quantity

received, and this list should be used by the bookkeeper in making the allowances.

Where the quantity for which invoice had not been billed is less than the inventory quantity, it is a simple matter to reduce the inventory accordingly, which serves the purpose just as though the material had not been counted in the inventory. It is, however, more troublesome if part or all of the material unbilled had been used; for instance, at the close of business December 31, 1918, you had overissued 500 feet of 6-inch pipe, and had 500 feet in stock, making 1000 feet for which the invoice had not been rendered, the 500 feet in stock should not be inventoried, and the value of the overissue of 500 feet should be recorded in the inventory sheets in red ink as a plus quantity to be deducted from the total inventory. In effect, by not inventorying the stock of 500 feet and deducting from the ledger balance the value of the overissue of 500 feet, you will have reduced the net inventory to the extent of the 1000 feet unbilled, which should be excluded because the inventory must equal the balance as made up from bills actually entered in your general ledger. In opening the ledger sheet for the succeeding year, post the plus quantity to the value of the overissue on the credit side, noting that this represents an overissue of the preceding year, so that when the outstanding invoices are received, the ledger sheet will show a debit of 1000 feet against a credit of 500 feet, leaving a balance of 500 feet, which represents the stock actually on hand December 31, 1918.

After making due allowance for all unentered invoices, each individual sheet should be closed by totaling the units and money value of all debits and credits, subtracting the latter from the former to ascertain the balance of unit quantity, unit cost and total value of what should be on hand. Then take an itemized list of the inventory sheets (using a set of mineographed sheets on which the inventory was taken) and rule up columns in the right-hand side showing the following:

DISCREPANCIES

ACTUAL INVENTORY QUANTITIES — FINAL INVENTORY VALUES

Units		Value	
Plus	Minus	Plus	Minus

MATERIAL STOCK RECORD

NAME OF MATERIAL..

MAIN STORE ROOM			DISTRICT STORE ROOM		
DATE AND REQ. NO.	RECEIVED	ISSUED	DATE AND REQ. NO.	RECEIVED	ISSUED

Figure 290—Material Stock Record, page 942.
(Actual size, 11″x15″—loose leaf)

The inventory quantity and final inventory value is then compared with the balances as called for on the stock ledger sheets, and all discrepancies are entered on the plus and minus columns to be carried forward to include a total of all items, which should, of course, show a net loss or gain, as the case may

be. The inventory, plus or minus the loss or gain respectively, should equal the balance charged to the stock account at the close of the year, and if there is a slight difference, the comptroller's figures are accepted and the difference is added (or deducted) to the net discrepancy, as any errors could not be located without a thorough audit of both the debit and credit entries on all of the ledger sheets for storeroom material.

Adjusting Discrepancies

In making adjustments, or charging off the discrepancy at the close of the year, it is considered equitable to adopt either of the following courses:

1. Retain for the unit figure the quantity actually in stock when the inventory was taken, and to the value of the inventory add the net minus discrepancy of, say, a class of appliances, thereby increasing the unit cost of each of that particular class of appliances, so that the discrepancy is really carried forward and charged off when the appliances are used during the succeeding year.
2. Furnish the comptroller with a statement of net discrepancies by classes of appliances and material, together with the total issues of each particular class by accounts, from which the discrepancies may be charged out as of the year in which the material was used.

This latter method seems to be the most satisfactory, saving the time and annoyance of changing unit prices.

However, no discrepancy should be charged off unless it is relatively insignificant or may be reasonably explained. As an illustration, suppose in one year there was a net loss of eight gas ranges which could be accounted for in a number of ways, such as failure to include in inventory some ranges that may have been loaned out or that may have been in consumer's houses and not connected, etc., and that the total net sales of ranges for the year exceeded 18,600, then this discrepancy would not be of sufficient importance to justify a costly investigation or a change in the system.

District Stock Cards

The question of expending large sums of money in installing an elaborate system for keeping track of storeroom material by additional unit district stock cards resolves itself into the degree of discrepancies, and when such discrepancies are held down to

a reasonable limit, it is likely that the money spent in tracing them would far exceed the value of the loss.

There are, however, discrepancies on brass goods, mantles, gas irons, and iron heaters, gas-stove lighters, toasters, etc., which, in a plant operating several district storerooms, become more or less annoying because of the probability of theft, as the articles are all small in size and quite easily disposed of. By opening at the main storeroom a composite unit stock record, Figure 290, for a limited number of items, on which is recorded the movement of stock shipped to and by each district storeroom, the stock on hand may be compared with what should be on hand at the close of the month. In this way, the main storeroom is in a position to investigate discrepancies more thoroughly, as it knows accurately the disposition of this particular material.

APPENDIX

The remarks below are intended to amplify, and in some cases, to bring to date, statements made in the preceding text.

Chapter II. Organization. The organization as described was somewhat contracted during 1918, but is now slowly expanding again. It has proved to lend itself readily to changing conditions. In some cases the change was made by abolishing positions, as, for instance, having but one general foreman for main and service work. Some of the positions of division superintendents were combined with those of district superintendent, but though one man might hold two positions, there was no confusion between division and district functions.

Chapter V. The Personal Equation. These words were written over ten years ago, but have not been changed, as the general principles stated still hold good. To be conversant with the labor problem, in all its details, from day to day, the employer must keep in touch with some of the many sources of information now available. A large organization without an employment division is becoming quite rare. Such a division should cover all departments of a gas company.

Chapter IX. Cost Reports. The statements are as of 1916, and, therefore, have to do with prewar costs. This is true of all other costs, absolute or comparative, mentioned in the book, which were not brought up to date of issue because there seems no reason to believe that the costs of 1919 will be any more valuable in 1920 or later years, than those of 1916. In these days of rapid change, no one year is like any other, and a comparison with 1916 is as easily made as would be the case with 1919.

Page 58. Radial Bends. The American Gas Institute standards do not provide for any bends of 60° curvature. Apparently there is slight demand for such specials, though, unless the city plan is almost exclusively rectangular, there are many occasions where these bends would be of great value.

Page 87. Steel Pipe. The National Tube Company has recently placed into use a process for removing scale that is expected to have material effect in decreasing corrosion. Some two-year tests indicate that the new material is fifty per cent better for hot-water pipes as compared with the previous standard iron or steel.

Page 93. Service Schedule. With the decrease in the use of gas for illumination, the number of rooms is no longer a direct measure of the future demand, and often there are no outlets to count. For this reason, in 1919 Philadelphia adopted a service schedule as below:

> The minimum size of a service for any building is 1¼-inch. In general, this size will supply any dwelling, or combined store and dwelling, of 12 rooms or less, provided gas is not used in any large appliance, such as an instantaneous water heater. In such event, and for all other buildings, the size should be calculated by the General Foreman.

Page 99. Service Drips. In some situations economy will be effected by the use of a welded drip.

Page 143. Drilling and Tapping Machines. Philadelphia has, within the last few months, used with success an application of an electric motor to a drilling and tapping machine. This has its greatest field of usefulness where the houses are built in solid rows, with one service tap every eight feet of main. Not only does power drilling result in more than doubling the workman's output, but also the threads are better.

Page 165. Motor Drip Wagons. The electric drip wagon is in its eighth year of satisfactory service, but the gasoline wagon is now doing the bulk of the pumping, which at present amounts to over one and one-quarter million gallons yearly.

Page 167. Leak Bars. There has been some use of electric power in making test holes for leak work. The Consolidated Gas Company of New York was the pioneer in this respect.

Page 178. Electric Safety Lamps. It is believed there is a field of usefulness for a farm lighting unit without battery, of, say, 1½ kw. capacity, to furnish light for night street leak work and also power for service tapping, leak test holes and thread cutting.

Page 201. Force Pump. A hand pump will probably be largely superseded, where conditions are favorable, by small tanks containing, at high pressure, gas or air for use in removing service or housepiping stoppages. Philadelphia's present practice in this respect will be published as part of the discussion on Mr. Charles R. Henderson's discussion on "Dust Deposits in Mains and Services," in the 1919 Proceedings of the American Gas Association."

Page 208. Horse Wagon. The horse is no longer used in Philadelphia distribution work. Motor experience indicates that because of low upkeep, the Ford one-ton chassis should be used as extensively as its capacity will allow.

Page 212. Electric Wagon. The equipment purchased in 1909 is still in as efficient operating condition as when new, all deterioration being completely met by current repairs. At present, ton for ton, with all costs considered, the electric is cheaper than the gasoline wagon, especially where operating conditions are such that seven or more wagons can be operated from one charging station.

Page 253. Cement Joint. The joint as pictured, and as described on the adjoining pages, has proved entirely satisfactory for pipe 12-inch and smaller in size when properly made. It is, however, not as strong as the joint recommended by the Committee on Cast-Iron Pipe Joints of the American Gas Institute and illustrated on page 321 of the 1915 Proceedings. For this reason this new joint should be used by every one adopting cement joints for the first time, or by any one experiencing trouble from cement joints made in any other way.

Page 256. Caulking Machine. This machine has never been placed upon the market.

Page 280. Power Rammers. Later experience indicates that hand pneumatic rammers are more generally useful under city conditions than a tamping machine.

Page 315. Steel Pipe on Bridges. There is an increasing tendency to use welded steel pipe on bridges, especially where these are of concrete and the pipe is completely imbedded in the bridge structure.

Chapter XXXIII. Electrolysis. There is a standing Committee on Electrolysis of the American Gas Association, and its annual reports contain the latest developments of this subject as it affects the gas industry.

Page 369. Schedule of Service Connections. In December, 1919, the Philadelphia schedule was amplified and changed to the following:

SCHEDULE OF SERVICE CONNECTIONS

Size of Service	Size of Main								
	30″	20″	16″	12″	8″	6″	4″	3″	2″
1 ″	1 ″	1 ″	1 ″	1 ″	1 ″	1 ″	1 ″	3″ S. S.	1½″ S. S.
1¼″	1¼″	1¼″	1¼″	1¼″	1¼″	1¼″	1 ″	3″ S. S.	1½″ S. S.
1½″	1½″	1½″	1½″	1½″	1½″	1½″	3″ S. S.	3″ S. S.	1½″ S. S.
2 ″	2 ″	2 ″	2 ″	2 ″	2 ″	1½″	3″ S. S.	3″ S. S.	1½″ S. S.
2½″	2½″	2½″	2½″	2½″	2 ″	3″ S. S.	3″ S. S.	3″ S. S.	
3 ″	3 ″	3 ″	3 ″	2½″	3″ S. S.	3″ S. S.	3″ S. S.	3″ S. S.	
4 ″	4 ″	4 ″	6″ H.S.	4″ H.S.	8″x4″T	6″x4″T	4″x4″T		
6 ″	6″ H.F.	6″ H.S.	6″ H.S.	6″ H.S.	8″x6″T	6″x6″T			

1½″ S. S. = Split sleeve with 1½″ tapped hole.
3 ″ S. S. = " " " 3 ″ " "
6 ″ H.S. = " " " 6 ″ hub.
6 ″ H.F. = 6″ Hat flange.

When a service sleeve is used, the cut or tapped diameter of the hole in the main should be the same as that of the service pipe, except for services 1¼″ and smaller, when the existing ¾″ or 1″ hole may be used.

When no service sleeve is used, and when the hole called for by schedule is smaller than size of service being installed, the enlargement to the size of the service should be made as close as possible to the main.

Page 370. Restriction of Tap Hole Diameter. Some experiments on this subject made by Mr. J. M. Spitzglass and published in the American Gas Light Journal of November 29, 1915, indicate that the restriction of the tap hole causes more pressure loss than was generally supposed.

Page 465. Tie-In Meter Connections. There has been further development in these connections (see Figure 135) since the text was written, and close touch should be kept with the manufacturers of these connections.

Page 480. Ebonite Washers. These washers are still in use and giving satisfaction.

Page 529. Check Test. The Committee on Consumers' Meters of the American Gas Association is now endeavoring to standardize the method of check testing. Their reports should be studied.

Page 547. Open Test. The 1919 report of the Committee on Consumers' Meters, as adopted by the American Gas Association, recommends the use of the open as well as the check test on all meters removed from service. By the use of the check test only, meters may be placed again in service whose registration will be incorrect at rates of use differing from the check test rate.

Page 636. Work Completion Schedule. This schedule, as well as the one on page 662, was true of prewar conditions. Present schedules do not call for such prompt work.

Page 641. Free Work Beyond Meter Outlet. As a result of increased operating costs, brought about by the war, few gas companies now are able to do any free work beyond the meter outlet. This is to be regretted from the standpoint of both consumer and company, for the amount of maintenance work done by the company has decreased tremendously, because in most cases either the work is not done, or a plumber is called in, and in either event the consumer does not get as good results as formerly.

Page 646. Removal of Service Stoppages. For the use of high-pressure gas to remove service stoppages, see the note on "Force Pump," page 944.

Page 688. Surface Combustion. This process has been very extensively developed in the last few years, and should be familiar to any one interested in use of gas for industrial purposes.

INDEX

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I

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